Vol. 15, No. 4 April, 1959

LUBRICATION ENGINEERING

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

Buffalo, New York—Site of 14th ASLE Annual Meeting

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

BROOKS OIL CO.
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THE FIRST OIL WELL in The UNITED STATES was located on Oil Creek at Titusville in Pennsylvania. Colonel E. L. Drake began work on this well May 20, 1859, and on August 27 of the same year struck oil at a depth of 69½ feet. The well produced thirty barrels a day for a year.

THE 100TH ANNIVERSARY OF THE OIL INDUSTRY

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Volume 15, No. 4
April, 1959

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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Awards Announced Final Plans Made For Annual Meeting

Added to last month's announcement of the bestowal of the National Award on Dr. M. E. Merchant, the ASLE Awards Committee has awarded other honors to deserving ASLE members.

John Boyd and A. A. Raimondi of Westinghouse Research Laboratories will receive the Captain Alfred E. Hunt Memorial Award. This award recognizes the best ASLE paper of the past year, "A Solution for the Finite Journal Bearing and its Application to Analysis and Design—I," published in the first issue of ASLE Transactions.

For writing the best paper as an ASLE junior author, F. L. Reynolds of Bridgeport Brass Co. will be presented the Walter D. Hodson Award. His article, "Mill and Laboratory Evaluation of Oils for Rolling of Copper Alloys," appeared in the March 1958 issue of Lubrication Engineering.

The Wilbur Deutch Memorial Award goes to A. E. Cichelli of Bethlehem Steel Co. for his paper "A Lubrication Engineer Surveys Steel Mill Gearing" in the October and November 1957 issues of Lubrication Engineering.

All awards will be formally presented at the April 23 banquet which wraps up the Annual Meeting. Following three days of conferences and meetings, this year's banquet will feature choice talent, paced by a remarkably agile acrobatic dancer.

Butyl Packings Successful for Press Operation

Fire-resistant phosphate ester-based hydraulic fluids have been in extensive use for several years, and their advent has substantially reduced the hazards inherent in the application of old style imflammable hydraulic mediums. However, these synthetics have posed numerous packing problems because these new fluids are not always compatible with existing packing compounds.

This was recently made apparent at the Alcoa, Tenn. plant of the Aluminum Company of America. A 250 ton hydraulically-operated wheel type press, operating at pressures from 500 to 1500 psi, is presently being used to straighten heat distorted rectangular steel smelter pot shells. The horizontal 18 in. stroke press has a 13 in. ram which was packed with a special duck and rubber "V" type packing when fire resistant fluid was first used as the hydraulic medium. Serious leaks developed around the stuffing box which could be stopped on the outward stroke by tightening gland. However, this necessary tightening caused excessive binding of the packing on the ram which made the counterweight type pull-back ineffective.

In an effort to solve the problems connected with packing and pull-back, Alcoa maintenance engineers applied a relatively flexible packing sets consisting of top and bottom adapters separated by C rings. This brought the leakage under full control and permitted use of the counterweight type pull-back by addition of a simple air cylinder. Butyl rubber packings are relatively new to the packing industry, primarily due to butyl's lack of resistance to mineral base oils. However, butyl's superior resistance to the rubber-destroying characteristics of pure phosphate esters has given the compound a new and important packing role.

PAST ASLE AWARD WINNERS

YEAR	NATIONAL AWARD	HUNT AWARD	HODSON AWARD	DEUTSCH AWARD
1948	W. D. Hodson	O. Maag	—	—
1949	C. F. Kettering	C. L. Pope	—	—
1950	L. G. Benton	W. M. Schuck	—	—
1951	M. D. Hersey	K. L. Hollister	—	—
1952	J. W. Stack	P. J. Galbreath	C. L. Miller	—
1953	J. J. Simon	D. G. Faust	A. C. West	—
1954	A. F. Brewer	E. E. Bisson	I-Ming Feng	—
1955	F. P. Bowden	F. W. Ocvirk	H. N. Kaufman	—
1956	O. L. Maag	B. Lunn	F. Osterle	—
1957	D. D. Fuller	D. Godfrey	E. Rabinowicz	—
1958	E. A. Ryder	L. F. Coffin, Jr.	—	Leon Salz

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Carol Joy's amazing acrobatic stunts have been applauded by patrons of the Moulin Rouge in Las Vegas and the Waldorf-Astoria Hotel in New York City.

Entertainment Galore At Annual Meeting

Buffalo Host Section Promises Good Talent

The toe-tapping of the Sullivan Brothers may set guests thinking back to the good old days of vaudeville.

Clinton Barry, whose Irish tenor has thrilled NBC audience, will act as master of ceremonies.

The pleasing song-stylings of the Antonelli Sisters will be featured with the popular music of the Benny Small Band, providing enjoyable dancing until midnight.

ASLE MEMBERSHIP CLASSIFICATIONS

Membership in the American Society of Lubrication Engineers is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted by the applicant.

Members: Members shall be persons not less than 24 years of age who: (1) are engaged in research and instruction at technical schools, universities, and various publicly and privately supported institutions in the field of lubrication; or (2) have occupied recognized positions as lubrication engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge, and accomplishment, and have manifested a particular interest in the purposes and welfare of the Society to the extent that their membership would be a valuable contribution to the successful functioning of its activities. Fee 15.00.

Associate Members: Associate Members shall be persons less than 24 years of age, and those who do not completely fulfill the membership requirements for Members. Fee $7.50.

Sectional Sustaining Members: are such persons or organizations as may be interested in and desire to contribute to the support of the purposes and activities of a local Section of the Society. Fee $25.00.

Industrial Members: Industrial Members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. Fee $150.00.

For application blanks or further information, write:

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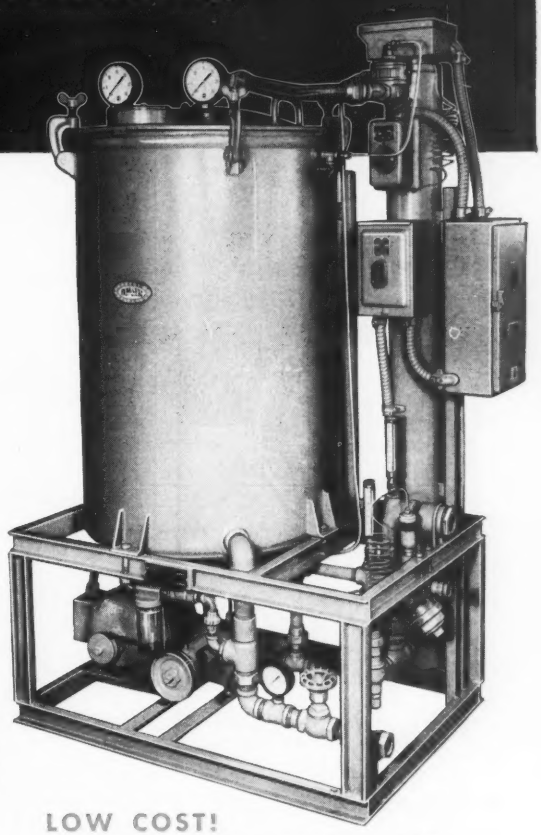

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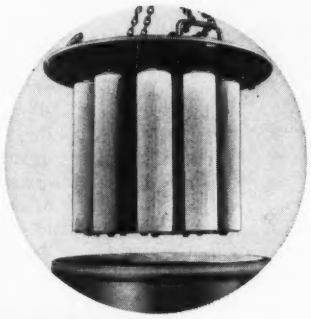

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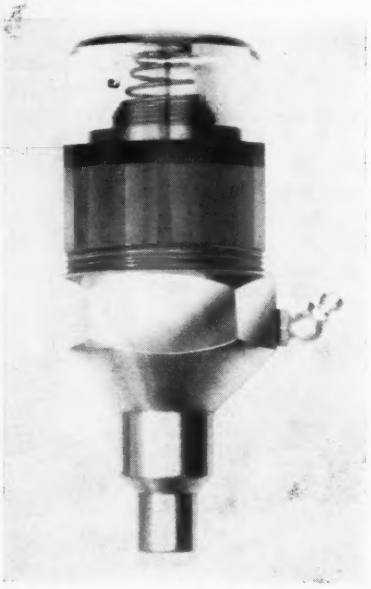
NEW PRODUCTS

KEY CYLINDER MOUNTINGS

A new shear key cylinder mounting has been adopted as standard for surface-mounted, square type cylinders by Hannifin Co. This arrangement allows quick, positive alignment of the cylinder in a keyway milled into the mounting surface. Key thickness is machined to close tolerances so that the keyway can be pre-milled with assurance of an accurate fit. Additional information about the "P" modification shear key is available from Hannifin Co., Dept. 312, Des Plaines, Ill.

AUTOMATIC GREASE CUP

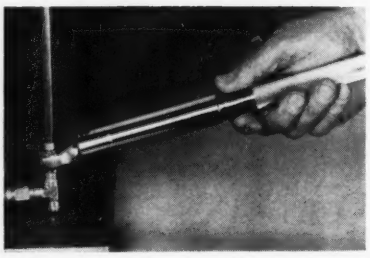
Automatic self-feeding lubrication with visible control is now possible for all plain or anti-friction bearings with new Lubrimatic grease cups. The grease cups feature a larger, four-ounce lubricant reservoir; vented clear, unbreakable plastic cylinder



for easy view of lubricant supply; spring and weighted plunger to feed grease to bearing with predetermined pressure; a protective valve that seats when cup is full, octagonal chrome-plated metal housing for easy installation; and internal ⅛ in. pipe threads in housing so that any size pipe or extension can be used to mount cup. Lubrimatic Grease Cups are manufactured by Lubriquipment Engineers, Inc., P. O. Box 9194, Fort Worth 7, Tex.

NEW TORQUE WRENCHES

A new line of pre-set torque wrenches specially designed for tightening flare nuts, has been developed. These wrenches reportedly assure positive, leakproof assemblies and eliminate the problem of awkward, time consuming fastening so often encountered with the extensions currently used with standard square drive torque wrenches. A complete line of four basic models ranging in size from ⅜ in. to 1½ in. is available. Torque values range from 20 lb to 3000 lb Specifications and price lists are available from the manufacturer, Skidmore Eng. Co., 5130 Richmond Rd., Bedford Hgts., Ohio.

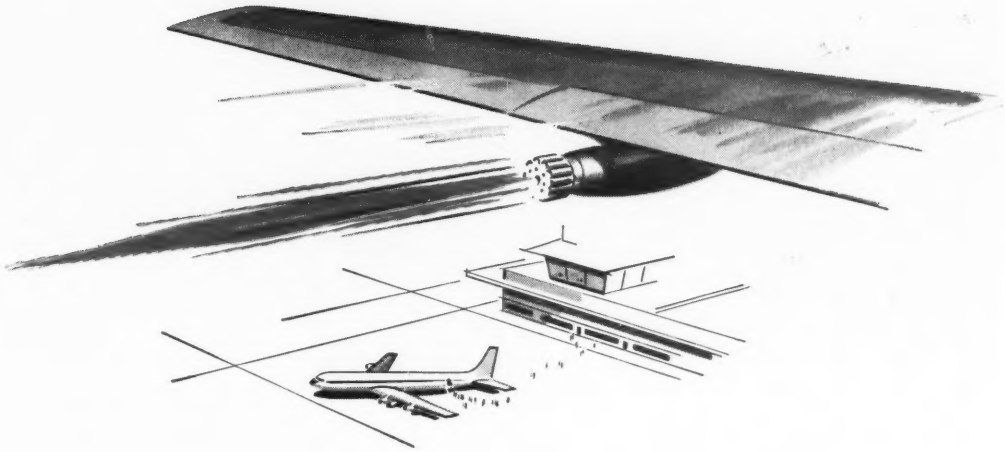


PROTECTIVE PLUGS ARE COLOR-CODED

A new line of patented polyethylene protective plugs has been developed. One of the features of the all-new line is the color-coding of each piece, to simplify inventory and stock room operations. In addition, easy-to-read size measurements are molded into the bottom of each plug. The protective plugs are tapered on the outside wall to match the pipe thread surface. However, the inside wall is vertical, assuring that additional wall thickness is provided at points of greatest stress. Suggested uses for these specially engineered protectors are: protection of bored, ground, polished, plated or painted internal surfaces; temporary sealing of valve seats, tubes and tube fittings; sealing-in oil, grease and rust proofing compounds for shipping; masking surfaces during plating, coating, anodizing, painting and other finishing operations. The protectors are available for immediate delivery in sizes from ⅛ in. to 1 in. inclusive for all standard internal pipe threads. Other sizes will be available shortly. For samples and prices write to Protector Products, Inc., Dept. LE, 2144 W. 15th St., Cleveland 13, Ohio.

SELF-LUBRICATING BEARINGS

Production of a new line of self-lubricating "Monoball" self-aligning plain bearings is announced by Southwest Products Co., 1705 So. Mountain Ave., Monrovia, California. The new bearings, which are being marketed under the registered trade name of "Dyflon", require no maintenance or service. The manufacturer recommends them for applications requiring low coefficiency of friction, long service life without lubrication and high dynamic load-carrying capacity.



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Commercial jet travel has arrived—and with it a whole new market potential for lubricants. And for synthetic base fluids, the industry is looking to Emolein Esters, the lube esters that have overcome the two major barriers to profitable commercial sales.

Performance requirements have been met by Emolein azelates and pelargonates, the bench-tested, flight-tested lube bases used in formulations meeting MIL-L-7808-C specifications.

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Please send bulletins: ☐ No. 411 (Emolein 2910 Pelargonate)
☐ No. 409A (Emolein Azelates)

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Company

Address

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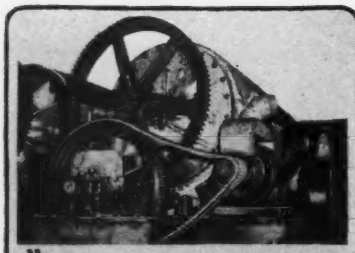

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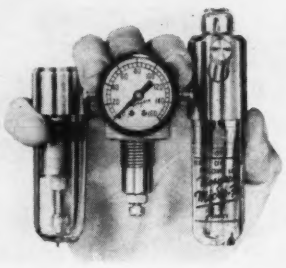
LUBRIPLATE is available in grease and fluid densities for every purpose . . . LUBRIPLATE H. D. S. MOTOR OIL meets today's exacting requirements for gasoline and diesel engines.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK" . . . a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

NEW PRODUCTS

COMPACT LUBRICATING UNITS

Two new, compact Lubro-Control units are now being featured by the C. A. Norgren Co., Englewood, Colorado. The smaller for ⅛ in. pipe installations measures only 4½ in. wide, 4¾ in.



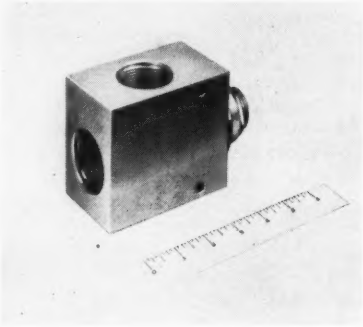
high and 3 in. deep. A slightly larger unit for ¼ in. pipe installation measures 7¼ in. wide, 5½ in. high and 3¾ in. deep. These new units provide complete and efficient processing of compressed air for service to air cylinders, air chucks, air tools, bearings and other machine components. Models are available for air flows from .05 to 20 cfm. Each unit consists of an air filter, a pressure regulator and a micro-fog lubricator. The *new*, small air filters provide efficient removal of corrosive liquids and abrasive solids from the air stream, preventing damage by these contaminants to connected air equipment. A pressure regulator is used in each lubro-control unit. It provides reliable regulation of air pressure and is adjustable over a pressure range of 5 to 100 psi. The lubricators provide efficient and adjustable airborne lubrication. They feature controlled oil delivery, transparent oil reservoir and oil feed dome for 360° visibility of oil feed rate, no tools required for servicing. Maximum line pressure is 150 psi; maximum regulated pressure 100 psi; maximum operating temperature is 120F. For details, write for Brochure No. 915B.

HYDRAULIC GEAR PUMPS OFFERED FIRST TIME IN U. S.

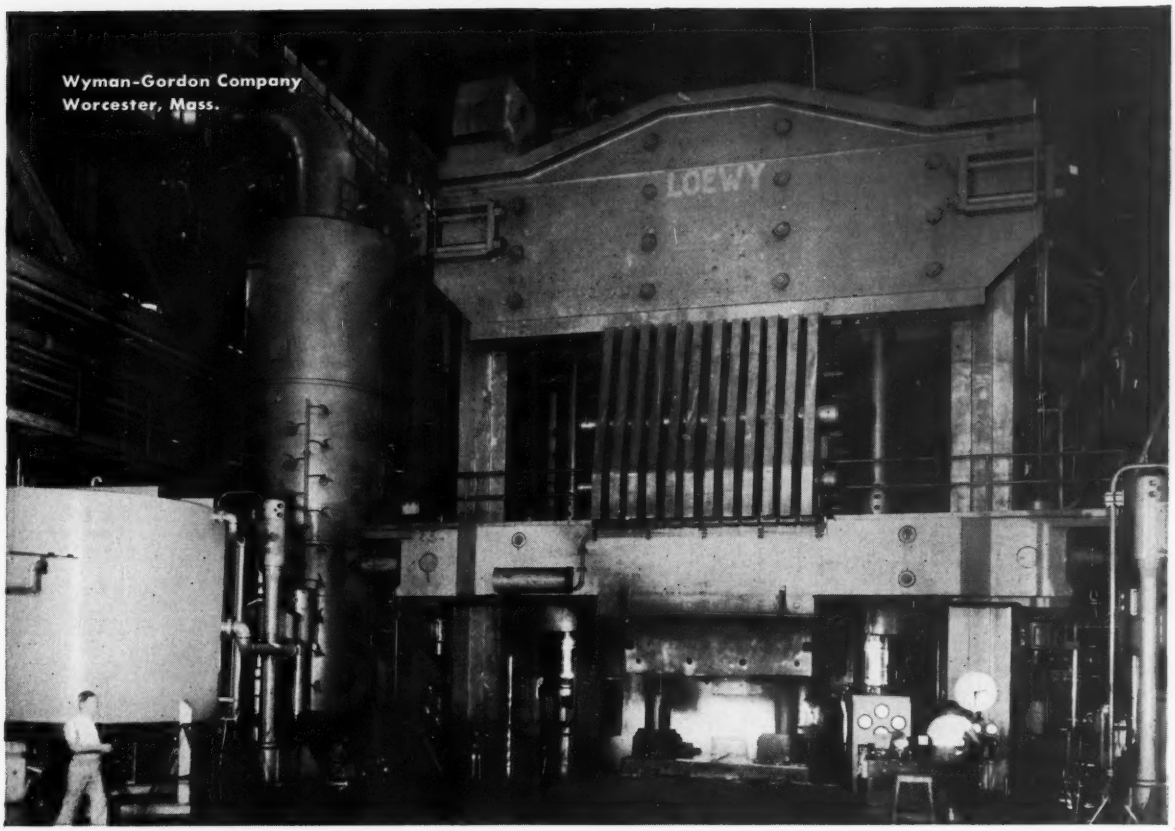
A complete line of pressure-balanced hydraulic gear pumps, developed in England by Dowty Hydraulic Units Ltd., is being offered for the first time in the United States by Berry Hydraulics, a Division of the Oliver Tyrone Corporation. Designed to operate at pressures to 2500 psi, the 14 sizes in four model groups have outputs ranging from one to 60 gpm. All sizes are available for either clockwise or counter-clockwise rotation. A cast aluminum housing combines strength and light weight. Medium size pumps in the line have a weight-to-horsepower ratio of under one lb per horsepower. Both flange and foot mounting are offered on all sizes. The unique cartridge construction features a minimum of working parts. Pressure balanced, self-compensating design eliminates the ma- superior performance over a wider range of operating speeds, pressures, temperatures, and oil viscosities than is possible in a conventional gear pump. Volumetric efficiencies exceeding 90 per cent are claimed. Noise level is low and pulsation levels remain practically constant in amplitude throughout the operating range. Complete information on the Dowty Pumps may be obtained by writing Berry Hydraulics, Oliver Building, Pittsburgh 22, Pa.

NEW RELIEF VALVE CONTROLS PRESSURES

A new large capacity relief valve designed to control pressure in hydraulic, lubricating and fuel systems is now available for use on ground handling



and support equipment. Pilot operated, the valve is chatter free with a capacity of 130 gpm. It has an externally adjustable pressure range of 50 to 1,200 psi. Pressure rise is only 15 psi at 55 gpm. Outstanding features of the new valve are said to be its negligible variations in the pressure rise and hysterisis curves. Its cartridge type design permits overhaul without disconnecting lines and fittings. Internal leakage at maximum pressure is 5 cu. in/min. maximum. External leakage is zero. The valve weighs only 4 lb 11 ounces, and is designed for 3000 psi proof pressure and above 4000 psi burst pressure. The aluminum body, 2 1/2" × 3 1/2" × 5 9/16", with stainless steel and aluminum cartridge minimizes maintenance and assures long life. Complete details are available from Fluid Regulators Corp., 313 Gillette St., Painesville, Ohio.



Operation Big Squeeze:

World's largest presses lubricated by Cities Service Pacemaker Hydraulic Oils

Once a forging operation for horse-drawn carriages, Wyman-Gordon Company now operates the world's largest presses, with the newest one capable of exerting 50,000 tons pressure.

Reason for this tremendous press is the increasing need for strong, lightweight metal parts for aircraft. Today, as for many years, no military or transport aircraft takes to the air without Wyman-Gordon forgings.

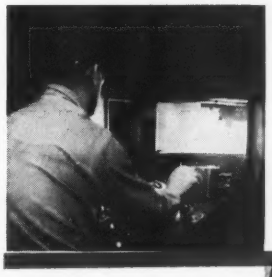
With its huge, hydraulically operated presses, Wyman-Gordon is able to forge huge pieces with one big squeeze. Sometimes a whole unit for a landing-gear strut. Or one mammoth wing spar.

The press that exerts 50,000 tons pressure is described by Wyman-Gordon as "the largest single machine ever conceived"—and few people would argue the point after seeing it.

Mounted in a pit that extends nine stories beneath the earth, the giant press is over 114 feet high and weighs 10,605 tons, 6,450 of which moves up and down.

Cities Service is justifiably proud that here as in all of Wyman-Gordon's presses with 18,000 tons pressure or better, hydraulic lubrication is provided by Cities Service Pacemaker Oils.

It is hardly necessary to point out the incredible demands that such machinery makes of its hydraulic lubricants... and certainly it is self-evident that if Cities Service Pacemaker Oils can perform satisfactorily in the world's largest presses, they'll do the same for you. Talk with a nearby Cities Service Lubrication Engineer. Or write: Cities Service Oil Co., Sixty Wall Tower, New York 5, N. Y.



Entire Rig Is Operated by One Man with the few simple controls shown here. With a flick of his fingers he can put on a squeeze of 50,000 tons. Result is extremely strong lightweight forgings for aircraft.

Lubrication Foreman has mammoth responsibility. Here, he checks dispenser for Cities Service EP 20 Lubricant... used on main bed and columns of large presses and other areas subject to extreme pressures.

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to
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PRODUCT LITERATURE

SOLUBLE OIL MIXER

Two-page bulletin explains how the Force-Flo soluble oil mixer inserts into a drum to accurately and uniformly mix soluble oil and water in the exact proportion required. Literature points out the savings in time, material, labor and space effected by the mixer that dispenses emulsion directly from the drum in 1/10 of the time normally required. Write for new bulletin to Force-Flo, Inc. P. O. Box 2442, East Cleveland 12, Ohio.

ORGANIC CHEMICAL CATALOG

Emery Industries offers a new edition of its catalog, listing product designations, descriptions, and specifications for Emery's line of organic chemicals. Included for the first time are the metholene fatty acid esters, as well as other individual products that have been added during the past year. Other organic chemicals that are covered in the brochure are Empol dimer acid, Emerox azelaic acid, Emfac pelargonic, Capric, and Caprylic acids, Emolein esters for synthetic lubricants, Plastolein plasticizers, Twitchell fat splitting reagent, and Twitchell and Emersoft textile chemicals. For a copy of the brochure, write Emery Industries, Inc., Dept. 5, Carew Tower, Cincinnati 2, Ohio, and request "Specifications and Characteristics of Organic Chemicals."

VALVE FINDER CATALOG

The Hannifin "Valve Finder," featuring an informative discussion of air valves and their selection, together with condensed catalog listings of the company's valves, is now available. The first section provides an explanation of valve terms and principles used in the air control valve industry. Included is a three-step outline covering valve types, means of actuation and operating principles to simplify choosing the exact air control valve best-suited for any application. The remainder of the 12-page catalog includes pictures, descriptions and catalog data on every air valve in the company's line. Copies of the "Valve Finder" are available from Hannifin Co., Dept. 312, Des Plaines, Ill.

ROLLER BEARING BUSHINGS

Jergens live roller bearing bushings are described in a new, six-page catalog. The catalog describes advantages and applications of live roller bearing bushings in jigs and fixtures, special machines and automation equipment, and use of live bushings in horizontal milling machine outboard support applications. Detailed reports by users, illustrations showing various live bushing applications, and dimension sketches and specification tables are included in the folder. For a copy of the new catalog, write Donley Products Inc., 11106 Avon Ave., Cleveland 5, Ohio.

BROCHURE SPECIFIES FOR ALUMINUM MILL PRODUCTS

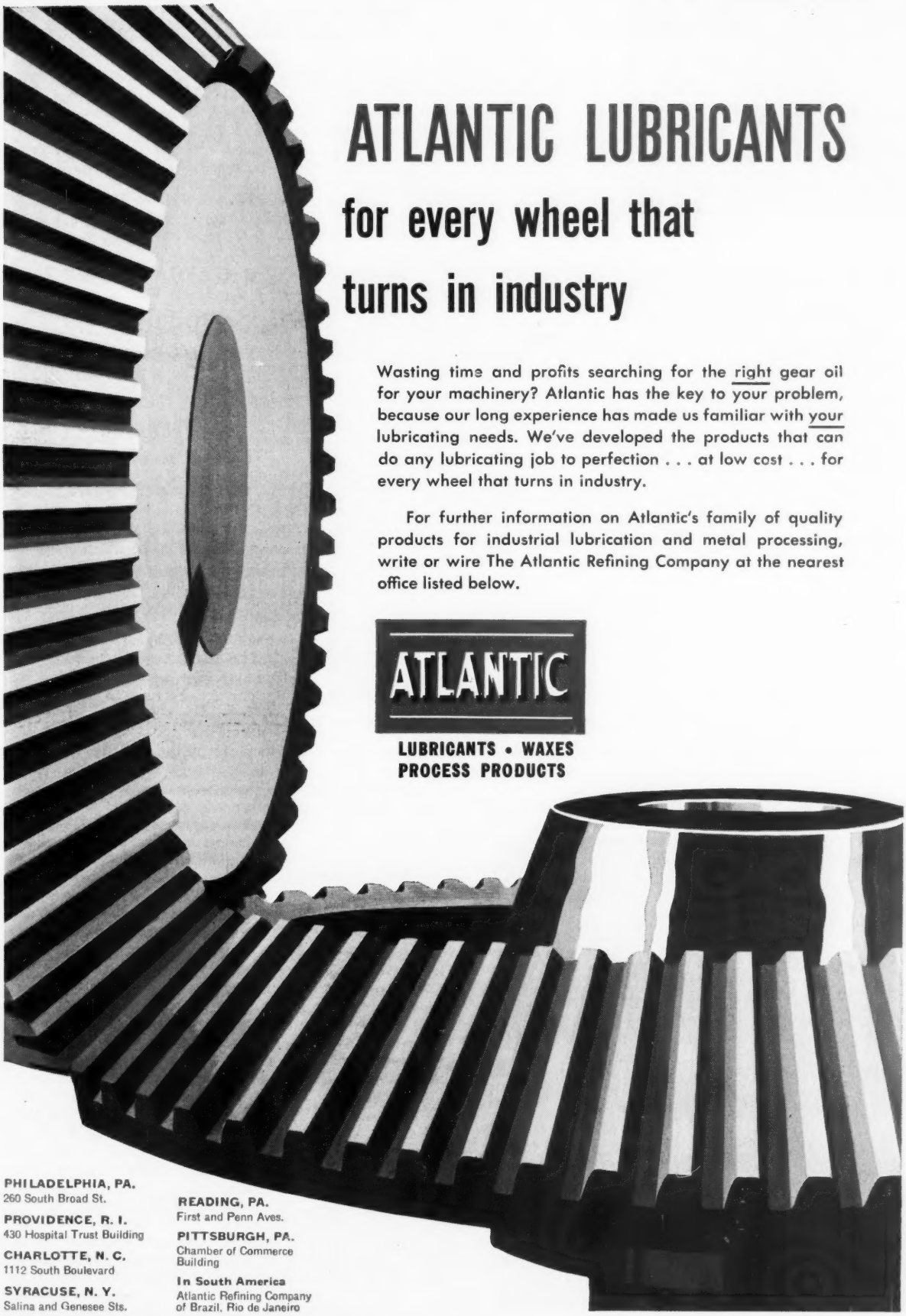
A new Reynolds aluminum mill products brochure gives complete specifications for the hundreds of alloys and forms of aluminum available from the company. The brochure enables designers, engineers and buyers to pinpoint specific properties and apply them accurately to the desired end use. Starting with a description of the light metal's classic advantages over other materials, the 18 pages include alloy and temper designations, fatique and shearing strengths, and various alloys available in foil, sheet and plate, wire, rod, and bar, tubing and pipe, and extruded and structural shapes. Fabricating and finishing techniques are summarized. A bibliography provides a guide to related literature and movies available from Reynolds. Copies of "Reynolds Aluminum Mill Products" may be obtained by writing to Reynolds Metals Co., Dept. PRD-1, Box 2346, Richmond, Va.

MOLYKOTE BULLETIN

Bulletin 120, a new two-color data sheet on Molykote wear-in compound, has been published by The Alpha Molykote Corp. The bulletin discusses the effectiveness of the new compound in eliminating the damage due to improper breaking-in of new or rebuilt machinery. Beside its basic use as a wear-in lubricant, the compound also is applicable to other troublesome friction applications in the average machine shop. Ordering information, including prices, is included in the bulletin as well as are photographs of the two-step method of applying the compound. Copies of Bulletin 120 are available by writing to the Alpha Molykote Corp., 65 Harvard Ave., Hartford, Conn.

NEEDLE THRUST BEARINGS

Catalog No. 759, covering needle thrust bearings with increased capacity ratings, is offered by The Torrington Co., Torrington, Connecticut. The booklet lists the complete line of bearings available in bore sizes from ⅜ in. to 3 in. In addition, the catalog has an expanded list of thrust races for use with these bearings. A copy may be obtained on request.



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Wasting time and profits searching for the right gear oil for your machinery? Atlantic has the key to your problem, because our long experience has made us familiar with your lubricating needs. We've developed the products that can do any lubricating job to perfection . . . at low cost . . . for every wheel that turns in industry.

For further information on Atlantic's family of quality products for industrial lubrication and metal processing, write or wire The Atlantic Refining Company at the nearest office listed below.

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Atlantic Refining Company of Brazil, Rio de Janeiro

Replete with symbols of their two societies are (left) J. H. Dunn, Cleveland SAE Section chairman, and George L. Smith, Cleveland ASLE Section chairman. The occasion was a recent joint SAE-ASLE meeting.

At same Cleveland meeting, speakers' table included (left to right): E. M. Johnson, guest speaker, E. Crankshaw, speaker's sponsor, T. Osters, ASLE program chairman, Dr. P. Asseff, ASLE regional vice president, and E. H. Scott, SAE vice chairman.

The second day of the Philadelphia Section-sponsored education course. The 59 men enrolled toured the Alan Wood Steel Co. at Conshohocken, Pa. and listened to a discussion of automatic lubrication systems and bearing types.

SECTION NEWS

Baltimore—A panel discussion was presented March 19 with guest speakers J. H. Wolfe, Jr., Black & Decker Manufacturing Co. and W. R. Hodges, Kaiser Aluminum & Chemical Co. On February 19, H. Landis lectured on "Fire Power." At the dinner meeting on January 15, W. Rosenberg spoke on "Lubrication Problems in Mechanisms." . . . **Chicago**—Dorothy Bond, nationally syndicated cartoonist, was special guest at the Annual Ladies Night of the February meeting of the Chicago Section. . . . **Cleveland**—A joint meeting of the Cleveland Sections of ASLE and SAE was held on January 19. E. Johnson of the Texaco Company, Beacon Laboratory, presented a slide-illustrated talk on "Vehicle Trends Effecting Fuels and Lubricants." The speaker's sponsor was E. Crankshaw, past chairman of the Cleveland Section. . . . **Duluth-Iron Range**—Henry Quesnel, Alemite Division of Stewart Warner Corp., was guest speaker at January 28 meeting. He showed a movie entitled "How Lubricants are Made." . . . **Houston**—A discussion of old and new aspects of automatic lubrication methods was led by L. R. James, Keller-Hyden, Inc. Models of the equipment were used for informative demonstration of this means of lubricant application. . . . **Kansas City**—T. P. Sands, Monsanto Chemical Co. cleared up questions on the subject of oil additives at February 16 meeting. . . . **Los Angeles**—At the request of many members, M. T. Flaxman, Wilco Co., led a discussion entitled "Cutting Oils; Formulation, Properties and Problems in Use" on January 21. . . . **New York**—The selection and application of metal-working fluids was discussed by R. Roger, Bijur Lubricating Corp. at the March 11 dinner meeting. The education course "A One Day Course in Practical Industrial Lubrication" was a complete success. 97 students were enrolled. At a previous dinner meeting on February 11, L. F. Horn, Vicker, Inc. discussed "Operation and Maintenance of Smaller Hydraulic Systems." . . . **Philadelphia**—Nine new members joined ASLE as a result of the recent successful education course given by this section. The course was made up of four sessions including three company tours and classroom discussions. . . . **Pittsburgh**—Seventy-six members and guests attended a technical meeting held on January 8. Eighteen additional men were present at the panel discussion which followed. Along with other scientific and technical societies in Pittsburgh, the ASLE Section is helping to promote Pittsburgh's bicentennial birthday. . . . **Rochester**—Lubrication Engineer, D. A. Hall, Eastman Kodak Co., presented "Use of Propane as an Engine

(Cont. on p. 134)

Now, from *Lincoln* ... the first really new air operated pumps on the market in 20 years!

THE *New* POWER-MASTER SERIES PUMPS

for lubricants and materials assure

- **Unmatched Versatility**
- **Top Performance**
- **Long Service Life**
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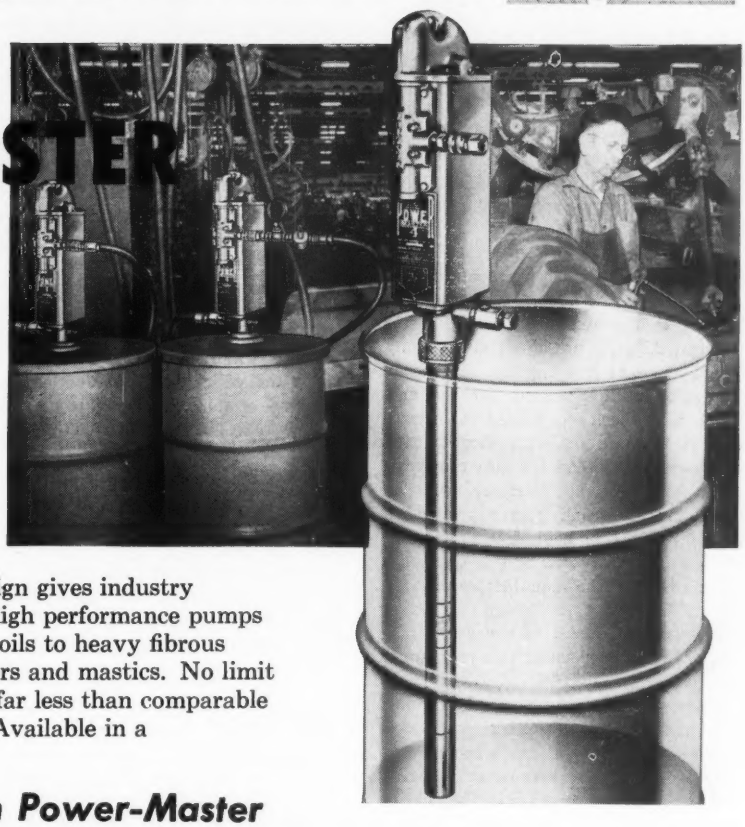

Power-Master ... years-ahead design gives industry a complete range of dependable, high performance pumps to handle all materials from light oils to heavy fibrous greases and viscous coatings, sealers and mastics. No limit to industrial applications ... cost far less than comparable pumps to operate and maintain. Available in a great number of pressure ratios.

It pays to standardize on Power-Master

HIGH VOLUME OUTPUT — **Air Motor** features extra long stroke for powerful, uniform delivery on both up and down strokes. **Shovel-Type Foot Valve** adds mechanical priming to normal suction ... assures positive prime with all industrial lubricants even at lowest temperatures.

STURDY CONSTRUCTION — Plunger and Bushing of case hardened Nitraloy steel ... prolongs life ... resists wear. Pump Outlet Body of all steel, one-piece construction ... hydrogen brazed. Withstands constant pulsation and extreme pressure. All moving parts are of tough, heat-treated steel.

TROUBLE-FREE, POSITIVE PERFORMANCE — Air Motor operation is 100% pneumatic ... no springs to wear out, rust, or lose tension. Air Valve is stall-proof, leak-proof and prelubricated ... toggle action assures positive tripping.

HIGH EFFICIENCY—Advanced design, double-acting **mechanisms** assure dependable low surge operation with minimum air consumption. Large **air passages** allow unrestricted venting.

PRECISION MADE—All mating surfaces of plunger, Bushing and Air Valve are microlapped to high tolerance ... prevents by-passing lubricant or bleeding off air. No washers or packings to replace.

SIMPLIFIED MAINTENANCE — Modular design of **Pump Tubes** provides extreme ease of disassembly ... invaluable when using compounds which may "set up," such as paints, plastics, etc. Entire mechanism can be assembled only "hand tight" and function perfectly for an indefinite period. **Air Motor Piston** and **Cylinder** ... No oiling required ... minimum friction ... no leather cups.

LIGHT WEIGHT — Generous use of aluminum makes **Pump** amazingly light in weight and distributes heat to prevent "icing" of **Air Valve.**

QUIET OPERATION—Exhaust port is free-flow in design and shielded by sleeve to produce a natural muffling effect.

INDUSTRY-WIDE APPLICATIONS—**Five Pump Tubes** are available for the POWER-MASTER series providing 19 ratios from 2 to 1, to 75 to 1. Meets all Industrial requirements. Handles all materials, from light, volatile solvents to heavy mastics.

For complete information on the new Power-Master series, contact your nearest Lincoln distributor ... and write for new Lincoln Catalog No. 65.

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INDUSTRY NOTES

Boric Oxide Plant In Design Stages

American Potash & Chemical Corporation has announced plans to construct the first large-scale commercial plant to produce boric oxide (boric acid anhydride). Boric oxide is used in manufacturing high-energy fuels, as well as various industrial applications.

The new facility will be located at the main American Potash & Chemical Corporation plant at Trona, California, according to the announcement by Peter Colefax, AP&CC president, at company headquarters at Los Angeles.

Design and engineering for the new plant have been completed. Construction is expected to begin shortly, with production scheduled for late this year.

An accompanying increase will be made in the Trona plant's production capacity of boric acid. Boric acid has various industrial uses and is the starting material in the manufacture of boric oxide.

The estimated cost of the new facilities to be installed under this program is approximately $800,000.

American Potash & Chemical Corporation first began pilot plant production of boric oxide several years ago as part of the company's long-range research and development program in the field of boron chemicals.

Polypropylene Plant Established in N. J.

American Viscose Corporation and Sun Oil Company have established an equally owned affiliate, AviSun Corporation, that is scheduled to be the nation's second and largest commercial supplier of polypropylene by mid-summer.

Sun scientists have developed a process for the manufacture of polypropylene resins and American Viscose researchers have developed new processes for the manufacture of polypropylene film and fibers. AviSun Corporation will be an integrated company for the manufacture, processing and sale of resins, film, fibers, elastomers, surface coatings and adhesives using olefin polymers or copolymers with other substances.

Commercial quantities of polypropylene resin are expected to be available by mid-summer from leased facilities of the Port Reading, N. J. linear polyethylene plant of Koppers Company, Inc. One line of the Port Reading plant is now being modified for polypropylene production using a process developed in the research laboratories of Sun Oil. Koppers will operate the process under the technical direction of AviSun. The capacity of the converted plant is estimated to be 20 million pounds per year.

Chalmer G. Kirkbride, executive director of Research and Engineering for Sun, has been elected president of AviSun Corporation. William H. Brown, vice president and treasurer of Viscose, was elected treasurer and assistant secretary of AviSun, and Joseph T. Wilson Jr., assistant secretary and assistant treasurer for Sun, has been elected secretary and assistant treasurer of AviSun.

PERSONALS

John S. Tawresey of Jenkintown, Pa. has joined the staff of The Franklin Institute Laboratories as a principal engineer in the friction and lubrication branch. His duties include a study of the influences affecting the life of rolling element bearings used in helicopter hub installation.

Dr. Leo J. O'Brien and Dr. Melvin A. Rosenfeld have been made directors of newly-created divisions at the Pure Oil Co.'s Research Center. Dr. O'Brien was named director of the production engineering research division, and Dr. Rosenfeld was named director of the exploration research division.

Professor Karl Dittmer, former head of the Florida State University department of chemistry, has been named program administrator of the Petroleum Research Fund, administered by the American Chemical Society. His offices are in the Society's national headquarters in Washington. Dr. Cary R. Wagner of Utica, Ohio, petroleum consultant, continues as chairman of the 19-man Petroleum Research Fund Advisory Board appointed by the ACS Board of Directors to solicit proposals and make recommendations on specific allocation of funds.

Stephen J. Luscian has been named southwestern area sales representative for American Cyanamid Co.'s organic chemicals division. Luscian will be responsible for the sale of all dye, textile chemical, intermediate, and petrochemical products of Cyanamid.

Lincoln Engineering Co. has appointed Robert C. Doss division manager with headquarters in Atlanta. His territory includes Mississippi, Tennessee, Alabama, Georgia, South Carolina, Virginia, and Northwestern Florida.

A. B. Two has recently joined the Motor Oils Refining Co. of Lyons, Ill. as lubrication engineer. He was formerly associated with the aircraft engine division of the Ford Motor Co. A member of the Chicago Section, Two is a national director of ASLE.

Russ Grothus has been promoted to assistant superintendent, building maintenance, at Bell & Howell Co.

SECTION NEWS

(*Cont. from p. 132*)

Fuel" at the March 11 dinner meeting. . . . **Saginaw**—During Saginaw Valley Engineers Week, an inter-society dinner was held on February 26. Dr. L. I. Doan, President, Dow Chemical Company, presented "The Chemical Industry and The Dow Chemical Company." Three-dimensional slides illustrating F. Sargent's recent European trip were shown by him on Jan. 29. **Toronto**—On March 10, A. J. Stock, Research & Development Manager, Acheson Colloids Co., spoke on "Emralon" coatings at a regular meeting. C. L. Pope pointed out the limitations of test specifications at a joint ASLE-ASME meeting. Pope, chief lubrication engineer of Eastman Kodak Company and past president of ASLE, was one of the 34 members of ASME elected a "Fellow of ASME during 1958." . . . **Twin Cities**—Slides illustrated Crane Packing Co.'s C. E. Schmitz's talk on "Analysis of Major Causes of Mechanical Seal Failures" at the February 26 meeting. At the January 29 meeting K. B. Wood, Jr., Climax Molybdenum Co., gave paper on "Molybdenum Disulphide in the Field of Lubrication." . . .

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Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Rimula Oils—for heavy-duty diesel engines

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Dromus Oils—soluble cutting oils for high-production metal working

Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

SHELL ALVANIA GREASE is available world-wide . . . assurance that your customers abroad will get the same performance from your equipment that domestic customers rely upon.

You can count on Alvania® Grease to remain plastic in sub-zero weather and, equally important, to remain stable under sustained high temperatures. On job after job, Shell Alvania Grease has successfully replaced dozens of special lubricants.

Alvania Grease also has an outstanding performance record on the toughest anti-friction bearing grease applications. It is ideal for wet, humid applications because it is inhibited to prevent water corrosion. It gives good lubrication under conditions which normally spell trouble.

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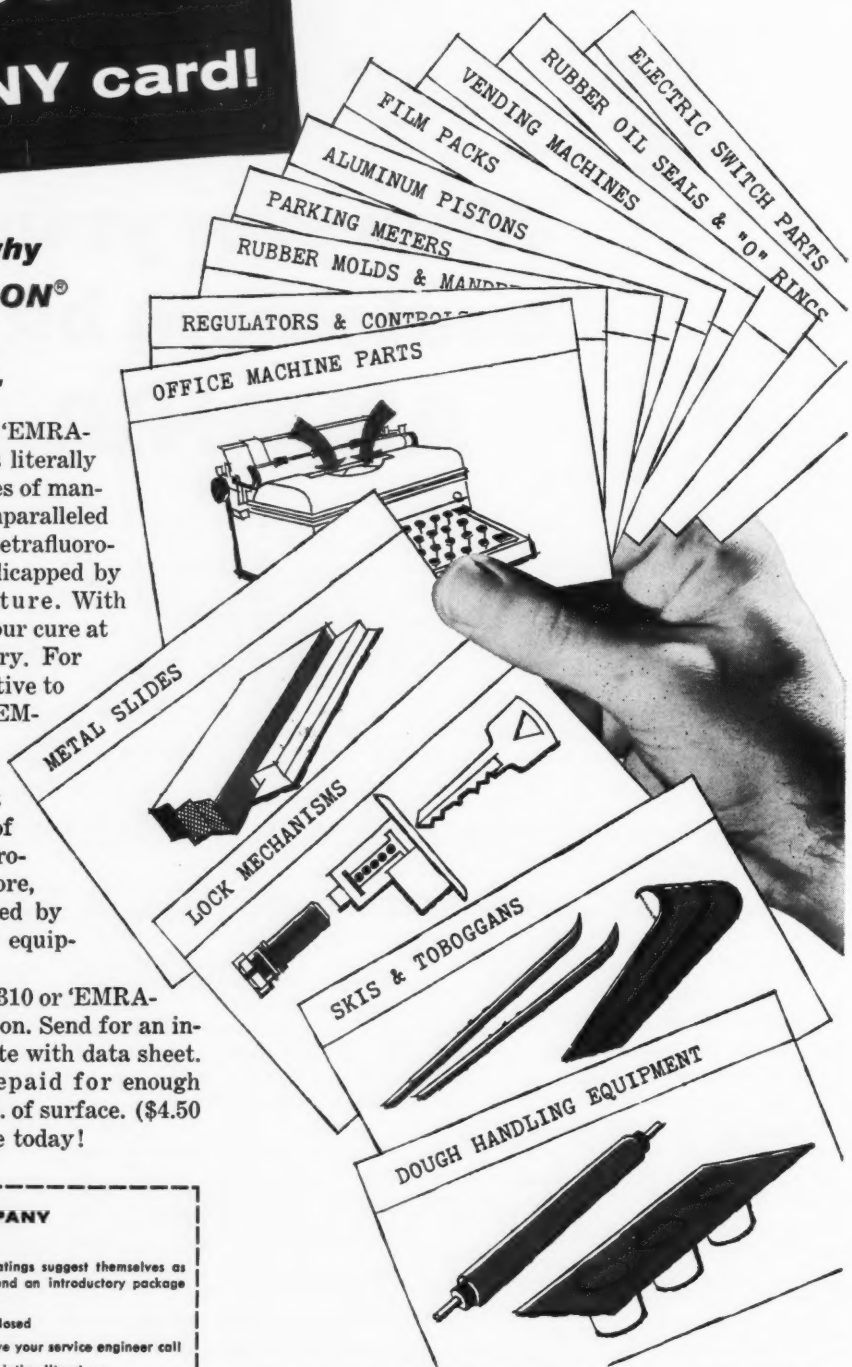

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The recent introduction of 'EMRALON' surface coatings has literally "opened the door" for scores of manufacturers seeking the unparalleled properties of du Pont's tetrafluoroethylene (TFE) but handicapped by the high fusing temperature. With 'EMRALON' 310*, a one hour cure at 300°F. is all that is necessary. For substrates even more sensitive to heat, there is air drying 'EMRALON' 320†. In either case, these versatile new coatings provide excellent adhesion, low coefficient of friction, toughness and corrosion resistance. What's more, 'EMRALON' can be applied by conventional paint spray equipment.

Why not test 'EMRALON' 310 or 'EMRALON' 320 on your application. Send for an introductory package complete with data sheet. The cost is only $4.25 prepaid for enough material to coat 5,000 sq. in. of surface. ($4.50 west of the Rockies) Write today!

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Gentlemen: Your new 'EMRALON' surface coatings suggest themselves as possibilities for a current design problem. Send an introductory package to me promptly.

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APPLICATION:

*'EMRALON' 310 is manufactured under exclusive license from E.I. du Pont de Nemours & Co. (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.
†'EMRALON' 320 — Patent applied for

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PORT HURON, MICHIGAN
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Lube Lines

by A. F. Brewer*

SEALS

Effective sealing is an adjunct to lubrication. If the lubricant can be kept in and the non-lubricating contaminants can be kept out, a machine will function more dependably. Dr. E. T. Jagger in the Dec. 1958 issue of *Scientific Lubrication,* has listed the five most important functions of seals in his paper "The Sealing of Anti-Friction Bearings." Those requirements hold equally as well for any other type of mechanism where lubrication is involved. Jagger's five functions are:

a. Preventing escape of lubricant.
b. Preventing entry of foreign matter into bearing.
c. Minimizing friction losses of the mechanism.
d. Ensuring simple and straight forward installation and removal of the sealing device during maintenance work.
e. Adding as little as possible to bearing cost.

Several types or methods of sealing assist in obtaining these objectives, but they must be selected and applied with due consideration of the operating factors which could affect seal efficiency such as vibration, high pressure, high sliding speeds, variations in clearance, temperature effect upon seal material, and harmful affect of certain types of lubricants.

Management must be concerned with this matter of sealing because production and cost of maintenance are involved. Production can be particularly important when fragile or perishable materials such as textiles, foodstuffs or beverages are being produced or handled. Textiles can be irreparably stained by oil drip or throw from a leaky bearing or by grease leakage due to overenthusiastic usage of a pressure gun which could force grease past a bearing seal. Foodstuffs or beverages contaminated by oil or grease drip obviously are not in keeping with pure food requirements. The worst factor in lubricant leakage past ineffectual seals is that the damage usually has been done before the cause is discovered.

INSTALLATION

Seal application can best be accomplished when the machine is on the drafting board. Then it is practicable to evaluate the merits of the various types of seals available with respect to cost and compatibility with prospective operating conditions. The ball and roller bearing industry, for example, follows this procedure to excellent advantage. It was natural that they should appreciate the value of dependable sealing for a prepacked bearing designed for virtual life-time service must sometimes function on less than an ounce of lubricant, according to the size.

Then again, the type and volume of lubricant must be considered. In an oil circulating system as involved in steel rolling, turbine or paper mill service, upward of several thousand gallons of oil must be protected by adequate sealing. Here, however, the pressure required for oil circulation is considerably less than in a pressure grease lubricating system where long delivery lines may be involved and the lubricant itself exerts far more resistance to pumping. In the one case seal tightness within the bounds of acceptable friction is most important; in the other, adequate resistance to pressure is required.

But the viscosity or consistency of the lubricant isn't the only criterion of its relation to the lubricating system. Its relation to the seal material is equally important particularly in the various synthetic materials such as synthetic rubbers. Here the source or base of the petroleum oil involved, either by itself or as a component of a grease, must be considered. Change in seal volume can become a serious matter. Research and exhaustive laboratory testing have indicated that, as a class, the paraffin-base oils which are low in relative aromatic hydrocarbon content are less apt to exert solvent effect and cause volume change of natural rubber and certain of the GR-S materials. On the other hand neoprene can be used more safely regardless of the base of the oil, although turbine grade refinement is most dependable.

SERVICE BEHAVIOR AND RESEARCH

Granted that there is as complete compatibility as possible between the seal material, the lubricant and the operating conditions, an added factor can influence performance. Windage or breathing past the seal due to pressure difference is a possible cause of rusting from moisture in the in-drawn air. Some highly interesting research studies made at Southwest Research Institute** have indicated that, on high speed gears, the ability of a lubricant to perform more dependably is improved by operating in an air-free atmosphere. Load-carrying capacity could virtually be doubled with certain types of E-P gear oils. This requires a tight system to permit exhausting the air. Such a system is obtained by predetermined construction or by the use of special and adequate sealing.

The fact that research is playing so important a part in machine design, seal application and lubrication certainly indicates that it is worthwhile and that it has the wholehearted encouragement of farsighted management.

* Consultant and author "Basic Lubrication Practice."

** Mechanical Engineering. Dec. 1958. p. 73.

NATIONAL OIL SEAL LOGBOOK

Ask yourself these questions when specifying oil seals

SHAFT RPM, FPM, RUNOUT, ENDPLAY	Is seal rated at or above my anticipated operating extremes? ☐ YES ☐ NO
TEMPERATURE, LUBRICANT TYPES	Will heat or special-purpose lubricants attack my sealing lip compounds? ☐ YES ☐ NO
PRESENCE OF DIRT OR OTHER FOREIGN MATERIAL	Point often overlooked. If present, should I specify dual-lip sealing member? ☐ YES ☐ NO
COST RELATED TO SEAL DESIGN	Will a simpler, less expensive seal do as good a job as a more sophisticated unit? ☐ YES ☐ NO
NEW SEAL DESIGNS AND MATERIALS ON MARKET	Are there new high temperature, high speed compounds I should examine before specifying? ☐ YES ☐ NO
SPECIAL DESIGNS FOR SPECIAL PROBLEMS	Not all sealing jobs can be met with stock seals. Do I need a special factory design? ☐ YES ☐ NO
DELIVERY, REPUTATION FOR QUALITY	Is my resource noted for on-time delivery, uniform quality, and good follow-up service? ☐ YES ☐ NO

Don't specify "blind." Your National Oil Seal Engineer has up-to-date data on seals —old, new and under development. He understands current sealing parameters; what special designs can probably be developed. His frank, free counsel can't help but lead to better sealing, faster assembly, simpler servicing, faster delivery or lower cost.

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NEW PRODUCT ISSUE

Stuart

Productive Lubrication

FOR PROFIT-MINDED PRODUCTION MEN

VOL. 1, NO. 3

MARCH-APRIL 1959

new

Stuart's HI-D* trims hidden costs on grinders at Torrington Bantam Bearing Division

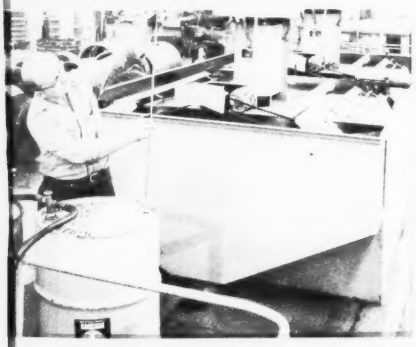
Proves high - detergency grinding fluid can be a flexible cost-reduction tool

This precision roller bearing manufacturer has found out what it takes in a grinding fluid to uncover hidden savings like these:

1. Less downtime for wheel dressing and cleaning machines.

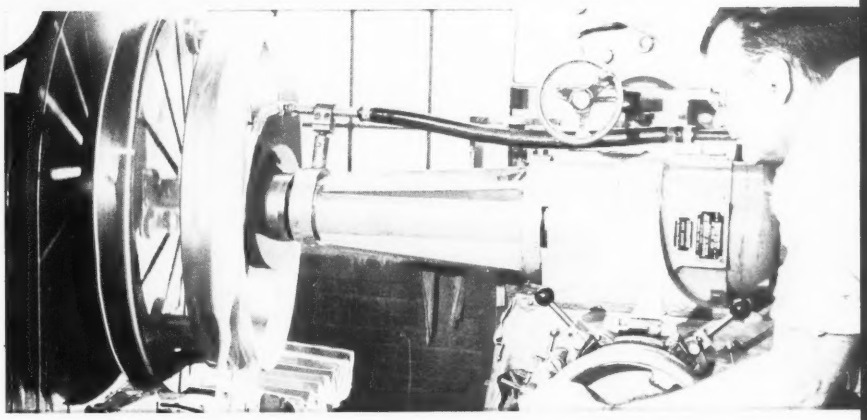
2. Longer wheel and diamond life.

The people at The Torrington Company, Bantam Bearing Division, South Bend, Indiana, diligently tested Stuart's new HI-D in a quest for mastery of chips and heat that determine wheel performance and work quality. They put it through its paces against six tough candidates to find the one best fluid for the average condition on 87 grinders—one that would perform most efficiently in their Hoffman flotation-type filter.



We were delighted, but not surprised, when Stuart's HI-D took top honors for both performance and economy. The reason is not too baffling. A new petrochemical detergent in Stuart's HI-D does a yeoman's job of keeping grinding wheels free-cutting. And in our opinion, the use of good "chemical soaps" for washing the fine hair-like chips from between the grits of a grinding wheel is a factor that deserves plenty of appraisal nowadays.

Torrington's efforts paid off. Today, wheels require dressing only ⅓ as often as they used to. Think of the savings from longer wheel and diamond life. But, even deeper benefits result from the elimination and control of downtime for dressing wheels. Wheel change time has been reduced, too, because now Torrington can do both roughing and finishing with a fine grit wheel. Formerly, two wheels had to be used.



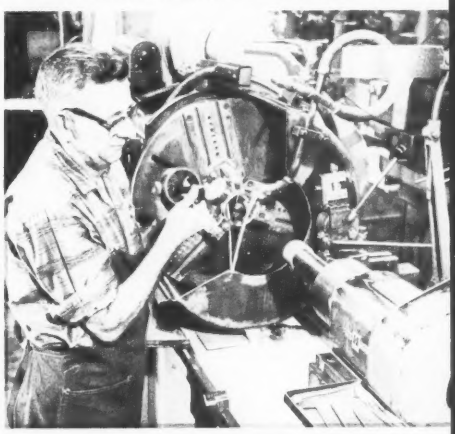
On machines like this universal gap grinder, wheels can remove .030" before dressing; whereas, previous coolants made dressing necessary at .010".

Solves chip removal problem

The hoe-and-wheelbarrow method of cleaning swarf from machine tools was abandoned by Torrington years ago. They float their chips and separate them in the central system. Hence, the grinding fluid must foam under proper agitation in the Hoffman flotation filter so chips can be winnowed out in a layer of rich lather. Elimination of chip carry-through is particularly important when grinding fine finishes on 52100, 8660, 4620, and E3310 Krupp, plus different grades of stainless, bronze, and aluminum. Stuart's HI-D proved to be 95% efficient in this respect. Only clean grinding fluid is returned to the machines and line obstructions due to chip precipitation have been avoided.

Reduces grinding fluid cost

Torrington reduced its coolant cost, too. Stuart's HI-D saved ⅓ the cost of the grinding fluid it replaced. The reason is, it stays on the beam at mixtures as lean as 60:1. The less expensive compounds lost their efficiency at anything greater than 40:1.



A three-month try-out on equipment like this proved Stuart's HI-D to be the best of seven grinding compounds tested at Torrington.

The cooling qualities of Stuart's HI-D at 60:1 produced another saving worth mentioning. Bryant "Centalign" grinders, which turn out small and very accurate bearings in the amazing time of 10 to 11 seconds, are hooked into the central system. With the former 16:1 coolant in the machines, the bearings came out hot. But now, with clean abrasive capable of cutting the metal instead of rubbing it, the bearings actually come out cool.

* Formerly: Dasco 102-M-18

MORE PL FACTS ▶

Stuart

Productive Lubrication

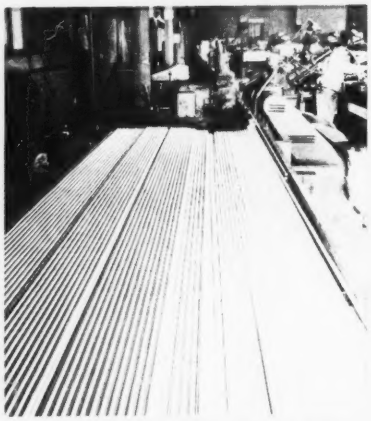
new

Stuart's HI-D* checks rust, reduces costs at La Salle Steel

Stuart's new high-detergency, wide-purpose chemical compound—HI-D—proved to be just what the people at La Salle Steel Company wanted: a cutting fluid that works equally well for grinding or turning, and is capable of inhibiting rust at economically lean mixtures.

During its preliminary evaluation, Stuart's HI-D was put on two Medart turners. We're happy to report (having more than a passing interest in this product) that it made a versatile showing and was immediately put to work on 9 machines in the grinding and turning department. Jobs ranged from roughing cuts of 1/16" to 1/4" on the turners to lighter cuts for accuracy and fine finish on the grinding machines. Which brings up one of the ticklish problems at La Salle . . . in-plant protection for highly finished steel bar stock.

In testing other lubricants, La Salle found bars rusted too readily at dilutions of 30:1. But Stuart's HI-D worked efficiently at a 50:1 dilution while it held its high detergency and lubricity potency for efficient turning and grinding. La Salle maintained quality and at the same time reduced cutting fluid costs plenty (45%).



Stuart's HI-D can be used at 50:1 on machines like this centerless grinder as compared with 15:1 for the previous compound.

If you're looking for a cutting compound that combines high detergency, rust prevention, wide job range, high cooling capacity, and excellent lubricity, it will pay you to call in a Stuart representative. Our real objective is even more direct — buy a drum of Stuart's HI-D and test it on your problem jobs.

* Formerly: Dasco 102-M-18

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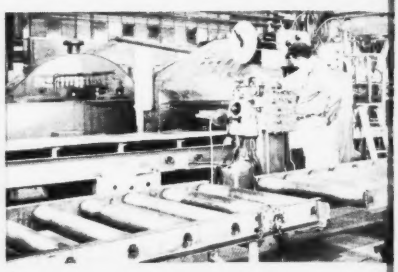


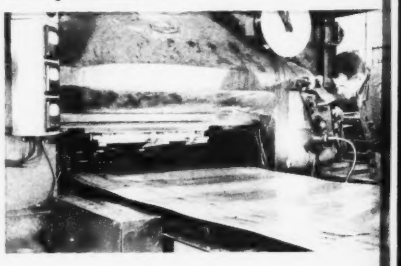
Flexible E.P. Rolling Oil boosts bearing life 50% on Sendzimir cold sheet mill

By using Stuart's Rol-Kleen 6 on their Sendzimir mill, Atlas Steels Limited, Welland, Ontario, stopped bearing failure due to lubricant breakdown — bearing life zoomed 50%.

Pumped from a 1700-gallon pit-installed tank to both bearings and work rolls, Stuart's Rol-Kleen 6 proved to be a real bear in the 21 bearings of the Sendzimir mill. Galling and spawling were eliminated. And yet it has the extra lubricity Atlas needed for rolling top-notch surface finishes on stainless and aircraft super-alloy sheets.

In the three years Atlas has used Stuart's dual-purpose Rol-Kleen 6, no bearing replacements have been traced to a lubricant failure. Reduction in maintenance has been a big factor in helping to control production at a profitable level.

Atlas turns out 2B and 2D finishes as well as light gage No. 4, using an E.P. type lubricant, Stuart's Rol-Kleen 6, for rolling as well as for bearing lubrication.



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Vol. 15, No. 4

Lubrication Engineering

ASLE honor roll

The members of a technical society such as ASLE realize that their group is made up of individuals, individuals who give of their time and effort in order to advance their own position, the Society's position, and the position of society itself. In order to give outstanding men in a group the recognition which they deserve, ASLE annually gives awards for outstanding performance in lubrication work.

This year's award winners take their places in a long and distinguished list of individuals (see page 122). Each award winner, past and previous, has contributed of himself and his knowledge in order to further the understanding of all those in this field.

The National Award—ASLE's highest award given in recognition of an outstanding contribution to the field of lubrication engineering—goes this year to Dr. M. E. Merchant of the Cincinnati Milling Machine Co. Carrying with it an honorary life membership in ASLE, this award honors Dr. Merchant for his outstanding research work in metal cutting and in fundamentals of friction and wear. It is also a fitting tribute to his leadership in ASLE activities, including his term as president in 1952-1953.

Three additional awards have been bestowed this year. To John Boyd and A. A. Raimondi, winners of the Captain Alfred E. Hunt Memorial Award for the best ASLE paper presented during the past year, to F. L. Reynolds, winner of the Walter D. Hodson award for the best paper by an ASLE junior author, and to A. E. Cichelli, winner of the Wilbur Deutsch Memorial Award for the best paper on the practical aspects of lubrication, the Society gives its hearty thanks. And its members express the hope that each year, from its ranks, will come individuals who in a like manner, will continue to advance their profession.

E. R. Booser, Chairman,
Awards Committee

Effect of New E-P Lubes on Elastomers for Oil Seals

J. Murray,

Chicago Rawhide Mfg. Co., Chicago, Ill.

The modern extreme pressure gear lubricant is designed for flexibility over a wide range of conditions, from low speed—high torque to high speed—shock load service. It is more than a lubricating oil. The E-P lubricant is a carefully blended compound of oil and chemical additives. It requires more than a standard oil seal to prevent leakage from gear case, differential, or axles. An effective seal for E-P lubricants must be oil and heat resistant and must resist attack of the highly active chemical additives.

WHAT ARE 'E-P' ADDITIVES?

When additives are referred to, reference is to the whole package of the specially compounded group of materials supplied by additive manufacturers to be blended into petroleum base lubricants. A classification of the chemicals which impart E-P characteristics to an oil reads like a list a rubber chemist might compile of materials which could be considered to have most detrimental effects on conventional synthetic elastomers. A partial listing of additives would include: active and combined sulfur, chlorinated compounds, phosphate esters, thiophosphate complexes, fatty acids, and various metallic salts and soaps. Each has an important role in stabilizing lubricant or promoting lubricity. The most active are effective only at rather high temperatures in the lubrication boundary zone which lies between the mating surfaces of interlocking gear teeth. This high temperature effectiveness, however, refers only to reactivity with metal to form a low friction film. Reactivity with elastomeric vulcanizates may occur at relatively low temperatures.

ADDITIVE CHEMICALS REACT WITH ELASTOMERS

There are a number of theoretical reactions which might occur between the chemicals of E-P additives and elastomeric vulcanizates. Active or free sulfur and combined sulfur compounds are used to vulcanize rubber. Hard rubber, or ebonite, is produced by adding an excess amount of sulfur to a rubber compound. It is understandable that a sulfur-vulcanized oil seal compound, when exposed to a lubricant containing free or combined sulfur at temperatures ranging from 200 to 300F, will become hard, even brittle, due to reaction at the surface with a material which is known to produce hard rubber.

A common practice in the rubber industry is to use metallic soaps to catalyze the rate of reaction between sulfur and rubber. So, in the E-P lubricant is found the active material to produce cross-linkages in rubber, reducing elasticity and promoting brittleness, and also a catalyst to speed this reaction.

Phosphate esters, fatty acids, certain classes of aromatic or halogenated compounds, cause rubber to swell because they are highly soluble in rubber. Swell, within reasonable limits, is not symptomatic of deterioration per se. Some of the effects of swell may hasten degradation of an elastomeric seal element. As one example, a swollen seal may press more tightly to a shaft with increased surface contact on the shaft. The resultant increase in rubbing surface will engender higher frictional heat. Heat will speed the mechanical and chemical processes that are, in effect, deteriorating to rubber.

These are a few of the possible chemical reactions between E-P lubricants and vulcanizates. There are also effects of the base oil which are common to all problems of lubricant sealing, so these will not be considered a peculiarity of E-P lubricants. The additive effect will vary with concentration. Since per cent additives varies with service conditions, discussion will be limited to concentrations in the 10 to 15 per cent range. At this level, the percentage of sulfur in the compounded oil may be as high as one per cent to two per cent and chlorine as high as 1.5 per cent to four per cent. Not all of the chemicals in the additive will be active. Some will react with other additive chemicals or with metal in gears, housing, bearings, etc. The reactivity with elastomers, if such occurs, may not be accurately determined by simple calculations of active materials available.

Presented before the 13th Annual Meeting of the American Society of Lubrication Engineers, April 22, 1958, at Cleveland, Ohio.

ROLE OF ADDITIVE CONCENTRATION

The proof of reaction with elastomers is to be found in beaker tests and in accelerated simulated service bench tests. A non-compounded SAE 90 base lubricant, i. e., one containing no E-P additives, does not deteriorate selected synthetic vulcanizates during reasonable periods of contact at elevated temperatures. The same base oil containing five, 10, or 15 per cent additive causes degradation of the same vulcanizates under the same conditions in proportion to the amount of additive used. The influence of as little as five per cent additive can be measured, but the critical concentration appears to be at 10 to 15 per cent, the commercial range for heavy duty applications. This is illustrated in Fig. 1. The effect of beaker tests conducted at 250 and 300F, for an immersion period of 70 hours is shown in photographs of vulcanizate test specimens. The specimens have been bent approximately 90° to illustrate surface cracking. Samples identified as *A* have been immersed in SAE 90 base oil containing no additive. There is no evidence of surface embrittlement. Samples *B* have been immersed in the same base lubricant containing five per cent additive. At 250F there is no effect but note the edge cracks after the 300F immersion. Samples *C* were immersed in lubricant with 15 per cent additive. The specimen after 250F exhibits light surface cracking and after 300F, immersion, cracking is deep. Samples *D* were immersed in a lead soap—active sulfur E-P lubricant. There is no surface embrittlement.

Visual evidence of deterioration varies with type of base elastomer tested. Degradation may progress to the extremes of hardening or softening. Excessive hardening imparts rigidity to the elastomeric sealing element and defeats the function of the part. A seal must be elastic to follow eccentric runout of the shaft or leakage will result. One of the effects of extreme softening has been discussed in describing effect of swell. A softened seal lip may also spread or flatten on the shaft, causing a wider band of rubbing contact and increased frictional drag. A softened seal lip may also be unable to support the load of a restraining garter spring and the spring may cut through to the shaft.

METAL MODERATES ADDITIVE EFFECT ON ELASTOMERS

The effect of E-P lubricants on elastomers is severe when tests are conducted in laboratory glassware. Effect may be minimized by incorporating metal in the test tubes. (SAE-ASTM Method D 471-55T "Changes in Properties of Elastomeric Vulcanizates Resulting from Immersion in Liquid" was used for all beaker tests.) By immersing varying amounts (0, 10, 20 grams) of fine cast iron filings into test tubes with lubricants and vulcanizates at 300F, some changes were observed. With increasing amount of iron present, precipitation or sludging diminished and degradation of elastomers was less pronounced. The finely divided metal may act as an active site for reaction of chemicals in the additive compounds. This is the effect that it was hoped might be illustrated. If these tests reflect a comparable reaction with metals in accelerated bench test units and in automotive gear cases, then the SAE-ASTM standard beaker or test tube immersion test is not suitable for prediction of serviceability of elastomers in actual automotive applications when E-P lubricants and, possibly, other compounded lubricants and power transmission fluids are involved.

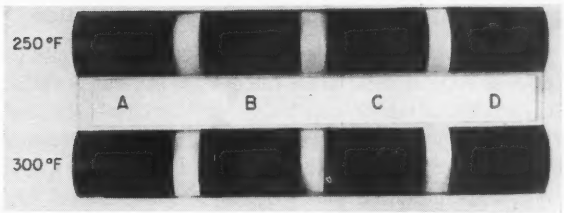

Fig. 1. Effect of temperature and concentration of E-P additives on elastomers.

Another test to determine activity of E-P gear lubricants in respect to elastomer deterioration was as follows: a series of nine E-P lubricant test samples of varying base oils and additives were measured into test tubes and nine specimens of an elastomeric vulcanizate were suspended in the tubes for a period of 70 hours at 300F. At the conclusion of the immersion period, it was observed that precipitate had formed in all but one of the test tubes and all but one of the elastomeric specimens were affected to some extent (by embrittlement, cracking, crazing). Only the specimen from the tube where no precipitate had formed was virtually unaffected. The nine lubricant samples were then filtered through several layers of parachute nylon cloth (filter paper would not permit passage of the lubricant) using a vacuum pump and Erlenmayer flask. The immersion test was duplicated using fresh samples of vulcanizate and the filtered lubricants. In none of these tests was the rubber affected and only two of the tubes had traces of precipitation. It has not yet been positively determined whether the filterable products are most active while in solution or are highly active insoluble combination products of two or more compounds. As indicated by tests discussed later, the latter is suspected. In all tests, the vulcanizate specimens were identical samples taken from the same lot of material.

Work is incomplete in the study of the effect of individual components of additives on the overall deterioration effected by the additive. Enough has been learned to date to make it possible to state that the larger part of the additive package is relatively inert in respect to reaction with elastomeric compounds specifically designed for use with E-P lubricants. A small part of the additive package is particularly deteriorating to elastomers at elevated temperatures. It is to be hoped that materials may be developed which will perform the required functions as additives and will be much less reactive with elastomers.

CHEMICAL AND PHYSICAL EFFECTS OF SLUDGE

Precipitation or sludging of most E-P lubricants in the test tube is a serious problem for several reasons. An accumulation of precipitate in the base of a test tube rises to the lower extremities of a vulcanizate test specimen suspended in the tube. That portion of a test specimen contacting the sludge at temperatures of 250 or 300F acquires a melted appearance, virtual depolymerization as evidenced by a plastic stickiness. This condition has been observed with all of the hydrocarbon type elastomers including the most recent of the heat and chemical resistant elastomers. There has been no observation of this kind in bench tests of seals, possibly because of circulation and the presence of metal.

The precipitate, which is an accumulation of reaction products dropped from solution or colloidal suspension, effects changes in elastomers on an exaggerated scale. Direct contact with the concentrated reactant serves to illustrate what may occur on a minor scale when these products, well distributed throughout a lubricant, contact an elastomeric seal.

Another problem created by sludge is the scale formed on the vulcanizate test piece. Measurement of swell or shrinkage of a test specimen by volume change is inaccurate to a large degree. The scale, by virtue of its own mass, alters the volumetric dimensions of the test specimen and its removal is difficult. Fig. 2 illustrates the scale formed on vulcanizate test specimens during immersion. Sample *A* has been immersed in SAE 90 base lubricant for 70 hours at 300F. Samples *B* and *C* have been immersed in a multi purpose E-P lubricant with 15 per cent additive for 70 hours at 250 and 300F, respectively. The lower portions of Samples *B* and *C* have been scraped clean and the accumulated scrapings may be seen below the test specimens.

Sludging has been mentioned as a serious problem in the beaker type test and probable reasons have been presented why the chemical effect of sludge on seals in a bench test does not occur to the same degree. In bench tests, reactions of additives with metal and dispersion of reaction products throughout the lubricant by circulation may prevent accumulation of sludge and moderate its effect. This does not mean that there is not a problem with sludge in accelerated seal testing. On the contrary, test units are badly coated internally after a 200 hour test period at temperatures of 250 to 300F. It has been found expedient to coat the interior walls of test units with polytetrafluoroethylene to assist in cleanup. As a result of the coating, cleanup has been reduced from eight hours to four hours.

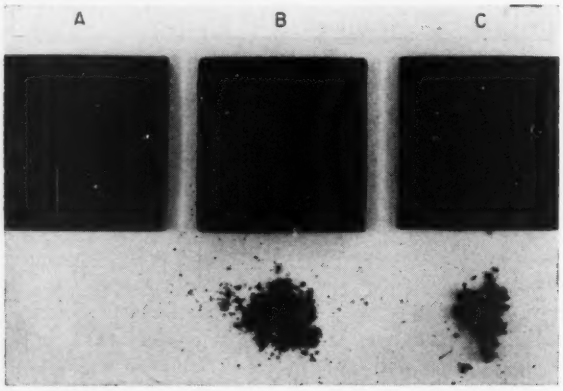

Fig. 2. Sludge accumulation during immersion in lubricant with 15 per cent additive.

Hard particles and sharp brittle slivers of precipitation products may and have been known to cut seal lips producing leakages.

TESTING AT ELEVATED TEMPERATURES

It is felt that many of the difficulties arising from use of very active E-P gear lubricants are centered in the high test temperatures established by automotive manufacturers' acceptance specifications. This is viewed only from one side of the problem, the position of the seal manufacturer. In a series of bench tests of seals made from an elastomeric compound which, admittedly, was not specifically designed for high temperature E-P lubricant service, the effect of temperature is well illustrated. Seals tested at 230F operated for 500 hours with no leakage, but identical seals tested at 250F leaked in 150 hours. Leakage resulted from deterioration of the elastomeric sealing element.

E-P lubricant which has been used in a bench test unit has a greater effect on the elastomeric seal element than new lubricant. This has been confirmed by test. Comparison testing was made of new E-P lubricant versus lubricant which had been previously used for 200 hours at 250F in a bench test unit. Both samples of lubricant were from the same drum and contained 10 per cent additive. Four oil seals were tested at 200F in new lubricant and four seals at 200F in the above-mentioned used lubricant. Average seal life of those tested in new lubricant was 200 hours before traces of leakage were observed. In the used lubricant, average time to trace leakage was 40 hours. This 80 per cent reduction in seal life was attributed to deterioration by chemical attack.

It is not proposed to discuss whether automotive test temperatures are realistic. The author cannot claim to know whether temperatures of 250 or 275F will be encountered in differential or hypoid gears. But the effect of induced temperatures in seal testing is known, and our knowledge is based on many thousands of hours of bench test experience.

Temperatures of 250F or higher are a very severe, and possibly over-accelerated, test of the oil seal and the E-P gear lubricant.

TYPES OF ELASTOMERS TESTED

Generalizations have been made in the use of the term "elastomer or vulcanizate." There are many types of synthetic elastomers. Tests have been made on 13 separate elastomers differing in basic polymer type and resistance to heat, oil, and chemical action.

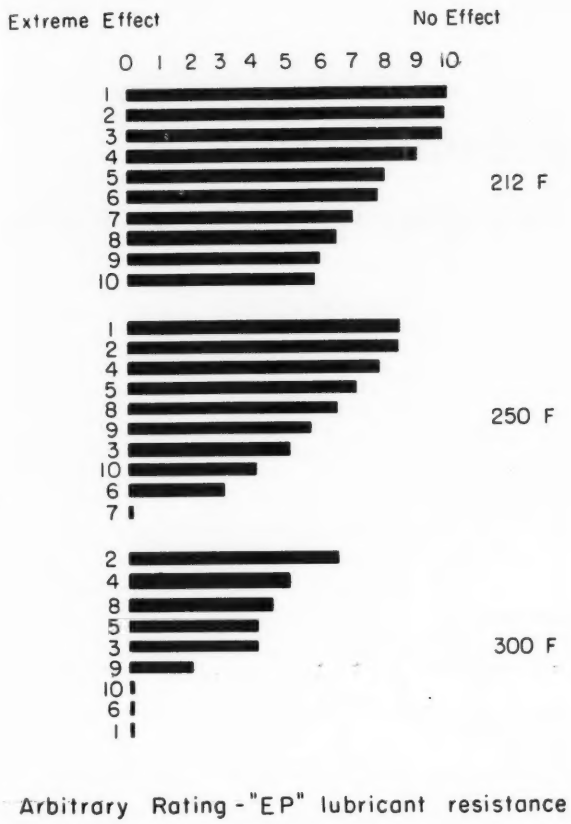

Fig. 3. Arbitrary rating—E-P lubricant resistance. See Table 1 for legend.

TABLE 1. IDENTIFICATION OF SAMPLES

SAMPLE NO.	CHEMICAL NAME
1	Poly Methyl Trifluoropropyl Siloxane
2	Hexafluoropropylene—Vinylidene Fluoride Copolymer
3	Polymer based on a polyacrylic acid ester
4	Poly 1.1—Dihydroperfluorobutyl Acrylate
5	Ethyl Acrylate and Chloro Vinyl Ether Copolymer
6	Poly Methyl—Vinyl Siloxane
7	Polychloroprene
8	Chlorotrifluoroethylene and Vinylidene Fluoride Copolymer
9	Butyl Acrylate and Acrylonitrile Copolymer
10	Butadiene—Acrylonitrile Copolymer

All were affected in E-P gear lubricant immersion in similar fashion, i. e. at some temperature consistent with the temperature resistance level of each polymer, each was deteriorated more rapidly in E-P lubricant than in SAE 90 base oil. Deterioration took different forms in different elastomers, ranging from embrittlement to extreme softening or tenderizing. This is illustrated graphically in Fig. 3. The identification of the individual samples is given in Table 1. Three sets of graphs show the effect of 70 hours immersions at 212, 250 and 300F on the several types of elastomers tested in an E-P lubricant compounded with 15 per cent additive. A rating value has been arbitrarily chosen. The high value of ten represents no change in elastomeric character of specimens tested and the low value of zero represents degradation to a non-elastic condition due to brittleness, tenderness, etc. The full bar, 10 units long, represents retention of 100 per cent of original properties and reduced bar lengths indicate that only a fractional part of the original characteristics were retained after immersion. It may be observed that all elastomers are affected in varying degrees by the increased activity resulting from temperature elevation. Compounds of three elastomer bases, vinylidene chloride, polysulfide, and a polyurethane, have not been included in the graphs because their properties after the 212F immersion were too poor to be included in comparisons with others in the group.

SEALING E-P LUBRICANTS IN THE FIELD

There is no intent here to predict that E-P gear lubricants cannot be sealed. Intensive laboratory investigations and testing have led to development of elastomeric compounds which are successfully sealing the E-P lubricants in the field and in accelerated bench tests. The primary aim is to report on the effects of beaker tests, and as a secondary goal to report on elevated temperature bench tests. Correlation has not been established between the two, nor has there been correlation between bench tests and field service. It is advisable to re-emphasize what is well known to all: Synthetic rubbers are organic compounds subject to change under chemical attack or elevated temperatures; so are lubricants. Oil seal and lubricant must, of necessity, be tailor-made for each other or an efficient job of lubrication cannot be done. The rubber industry is continually designing oil seals for specific lubricants used in a variety of applications. It is known that lubricant chemists would prefer to develop their materials to be compatible with available seals, but sometimes find this impractical or impossible.

It has been an often expressed hope that cooperative research investigations into lubrication and attendant sealing problems, may eventually include lubricant and seal manufacturers and, also, the ultimate user of the two products, the equipment manufacturer.

In the past year or two, test programs have been conducted in close cooperation with manufacturers of several additive and petroleum products in the interest of providing most effective service to customers.

ACKNOWLEDGMENT

The author wishes to acknowledge the help of those who cooperated in furnishing samples of E-P lubricants for test. He desires, particularly, to acknowledge cooperation of the Lubrizol Corp. with whom his company has been studying additive components and their individual effects on elastomers. More widespread usage of the new E-P additives has promoted accelerated activity in these studies. The author also wishes to thank the members of the technical staff of the Sirvene Div. of the Chicago Rawhide Mfg. Co. for their cooperation in preparation and presentation of this paper.

Radioactive Determination of Bearing Wear in a Refrigeration Compressor

G. R. Fox and R. C. Elwell,

General Electric Co., Schenectady, New York

The lubricant and refrigerant mixture viscosity in a hermetically sealed refrigeration compressor varies widely with changes in system pressure and temperature. In this article, theoretical load carrying capacity at different operating conditions is compared to actual bearing wear determined by radioactive methods. This technique allows a continuous and rapid evaluation of a complete fluid film bearing system.

A special lubrication problem in hermetically sealed refrigeration compressors is dilution of the oil by dissolved refrigerant. The amount of dilution and the resulting lubricant viscosity vary widely with temperature and pressure. Also, the type of refrigerant and type of oil each affects solubility. In this investigation, the refrigerant used was monochlorodifluoromethane, commonly known as Freon-22 and G-141. Two different oils were evaluated—one a white paraffinic mineral oil of 200 viscosity, the other a naphthenic of 150, both at 100F.

Excellent comparisons of the dilution characteristics of paraffinic and naphthenic oils in the presence of refrigerants are available (1, 2, 3, 4). Fig. 1 shows the amount of F-22 dissolved by the naphthenic oil at various ambient conditions.

If the compressor operated at one cycle condition, there would be no real problem in bearing design, because the lubricant viscosity could be easily determined from known conditions. In nearly all hermetic compressor applications, however, various duty cycles are imposed, each of which produces a different pressure and temperature in the oil sump. As the machine goes from one cooling load to another, it therefore traverses, and sometimes exceeds, the ambient range in which dilution is predictable.

The values in Fig. 1 are at equilibrium conditions. Time required to reach equilibrium dilution varies from a few minutes with low viscosity oil to several hours for very viscous oil, so that certain cyclic loads may never establish the dilution predicted in Fig. 1 (3).

The degree of oil sump agitation is also very important to the time required to reach equilibrium (1).

Presented before the 13th Annual Meeting of the American Society of Lubrication Engineers, April 23, 1958, at Cleveland, Ohio.

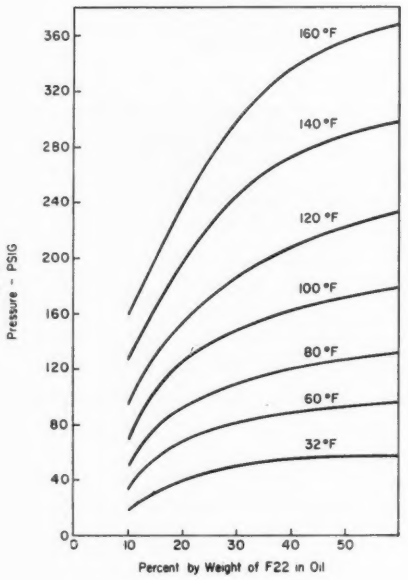

Fig. 1. F-22 Solubility in naphthenic oil.

Because of this fact, any compressor design will have its own lubrication peculiarities.

In this application, analyses of bearing load capacities were based on estimates of the lubricant dilution. Because of the uncertainties arising from these estimates, a test of the design under actual operating conditions was necessary.

A radioactive bearing wear measuring technique was decided upon for several reasons. By continually monitoring the wear, the worst load conditions can be instantly detected. The final wear rate, and accumulation of wear, allow extrapolation to a predicted life of the machine. Any peculiarities of the system or critical operating points show up immediately. Designs can be quickly and sensitively compared. An incipient failure can be detected by a sudden sharp rise in wear rate.

TEST DESCRIPTION

Fig. 3 shows a schematic diagram of the compressor assembly. The two upper main bearings, between the motor and cylinders were the objects of the investigation.

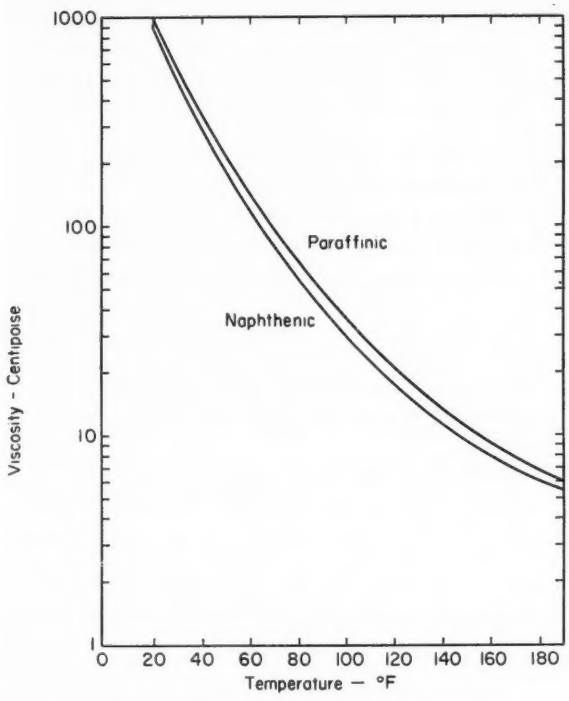

Fig. 2. Viscosity-temperature characteristics of test oils.

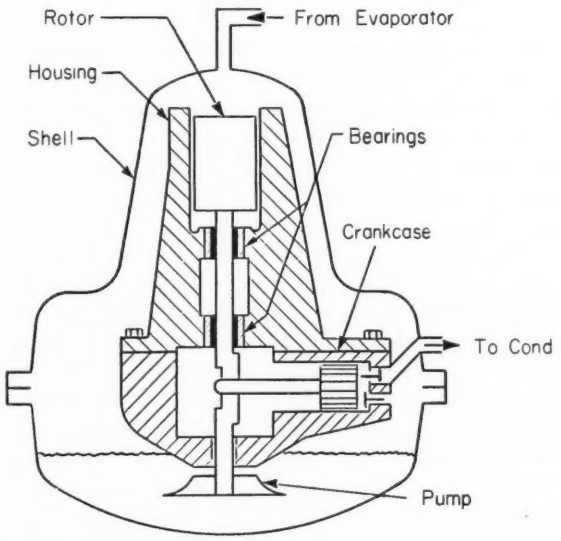

Fig. 3. Schematic drawing of compressor.

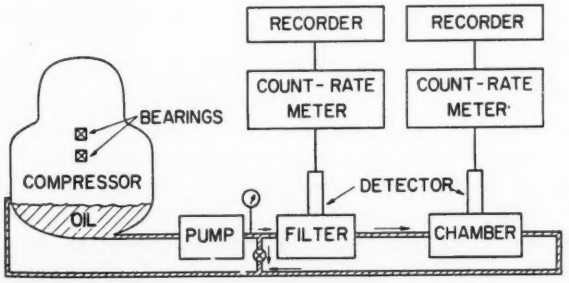

Fig. 4. Schematic diagram of bearing wear test.

These bearings were babbitted steel split inserts. Each was one in. long by one ¼ in. diameter, with 0.020 in. thickness of babbitt cast on the 0.050 in. low carbon steel backing.

The general method followed in the test was to activate the bearing insert, and circulate lube oil containing wear particles past an external radiation counting system.

A schematic diagram of this system is shown in Fig. 4. Wear particles from the bearings are flushed naturally down into the oil sump. There they are continuously sampled by the external pump, which draws from the bottom of the compressor shell. The liquid first passes through a 10 micron filter which is monitored by a scintillation detector for accumulation of the larger radioactive particles.

Very fine particles of less than 10 microns will pass the filter, however, and remain uniformly suspended in the oil. These are monitored by a second detector which "sees" a chamber in the line. This counting rate gives the concentration in a known volume of lubricant, which can be used to estimate total amount of suspended material.

The pressure drop across the filter and counting chamber was maintained at 30 psi in all tests.

It should be noted that a reliable filter and pump were the most difficult parts to obtain. These units had to contain the mixture with absolutely no leakage at pressures above 200 psi. The filter consisted of a commercial filter element and a welded steel case which was fabricated in a nitrogen atmosphere. The pump was a hermetically sealed unit with shaft seal leakage contained in a pressure vessel surrounding the stator.

The scintillation detectors fed into count rate-meters and then to chart recorders. Details of the activity calculations and possible errors in measurement are given in the appendix.

Fig. 5 is a photograph of the equipment diagrammed in Fig. 4. The compressor is at upper right. As a safety measure, the entire pump loop is contained in the welded steel tank at the left. This tank was intended to catch any leaks of radioactive material.

The small pressure gage indicates filter and chamber pressure drop in the pump discharge line. Left of the gage is the filter, then the counting chamber.

Absent from the photograph are some 400 lb of lead shielding, and the scintillation detectors. The filter and chamber were completely shielded in operation.

All copper lines connecting the loop to the compressor were made with gradual bends in them to prevent settling of particles (Fig. 5).

The bearing inserts were irradiated in an atomic pile. Detailed radiation procedures are given in the appendix. Some bearings were processed by Brookhaven and some by Argonne National Laboratory. The cost of irradiating a bearing varied. Ordinarily four to six were put into the pile at one time, and the charge for the group was $100.

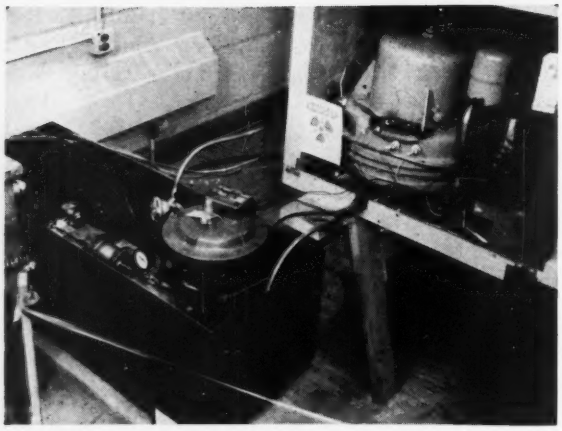

Fig. 5. Photo of wear test. Compressor at upper right; pump, filter, and chamber in tank at left.

Two types of bearing materials were evaluated separately, one a babbitt, the other a copper lead alloy. Their nominal compositions were as follows:

Babbitt	*Copper Lead Alloy*
89.0% Sn	72.0% Cu
7.5% Sb	23.0% Pb
3.3% Cu	3.0% Sn
	2.0% Zn

In the case of the babbitt bearings, antimony 124 was used as the tracer; this has a half-life of 60 days. Zinc 65 with a half-life of 250 days was the tracer used in the copper lead bearings. These relatively long half-lives assured good sensitivity throughout the test, and removed the necessity of hasty assembly.

The radioactive bearings were bored to final size after they were pressed into the housing. Following the machining operation, the compressor and motor were assembled and sealed in the outer shell. Scrupulous attention was given to the clean-up of radioactive chips and tools at all stages of the machining.

These operations were carried out by machinists with no previous experience in handling radioactive materials. These men were instructed in proper safety precautions and each operation was practiced using non-radioactive bearings. Radiation safety specialists reviewed the assembly plans for potential hazards and monitored actual operations.

The assemblies were made no oftener than once a week to keep an individual's radiation dosage within a specified maximum of 60 milli-roentgens per week. No individual dose exceeded a total of 130 mr in the course of seven radioactive assemblies, using the same personnel throughout.

The average bearing unshielded had a radiation level of 500 mr/hr at a distance of one foot. After installation of two of these bearings, the radiation level was 60 mr/hr on the outside of the compressor shell.

The assembled system was leak tested, and the unit charged with F-22 and oil in the normal manner. The pump loop was then run to establish the initial radiation levels at the scintillation counters. This was intended to scavenge any stray pieces of radioactive material which might have been loose in the compressor shell. Following establishment of this initial state, the compressor was started with its own controls and the test begun.

A test usually took about two weeks, during which time a continuous record of wear was kept.

Following a test, the refrigerant charge and oil were bled off through a strainer. The compressor was then disassembled. Visual and autoradiograph inspections of the bearings and shaft were then carried out.

The outer shell was cleaned up for re-use until negligible radioactivity could be measured. The remaining parts of the assembly, such as the motor, were not so easily decontaminated, and these were discarded.

Oil samples from some units were tested for the size of particles they contained as a check on the filter effectiveness. This was done by placing an oil sample on the top surface of a tall column of heavier oil and measuring the time for the radioactive particles to drop a known distance between two scintillation counters. Stokes' Law for small bodies travelling in a viscous medium then was used to predict distribution of particle size.

RESULTS

Early in the development of this compressor, it became evident that analysis of the bearing load capacity would be extremely difficult to accomplish accurately. No matter how rigorous the analysis, several large unknowns in the operating variables still prevented an accurate solution. Then too, several different operating conditions would be imposed on the compressor system, requiring this work to be done several times.

Nevertheless, an analysis of the bearing load capacities was performed for one design configuration and the results compared to the wear tests. Theoretically, this should not have been done, since hydrodynamic theory is based on the shaft not contacting the bearing, whereas the wear tests measure exactly the opposite situation. It was expected, however, that a relative order of operating condition severity would emerge from the analysis, and that this could be related to the magnitude of wear found under these conditions in test.

A relative order of loading severity indeed resulted from the analysis, but the differences in the load capacities as theoretically predicted were too small to be important to the wear process.

Some limited correlation was observed, however. The curve on Fig. 6 shows the calculated load capacity at an eccentricity ratio of 0.8 versus lubricant viscosity. Steady loads were assumed, and the method of Reference 5 used to predict eccentricity ratio.

Also shown on Fig. 6 are three actual loads at their estimated viscosities. Load condition *a*, if the viscosity estimate is accurate, has sufficient margin of safety. Condition *b* should also be safe, but *c* is marginal.

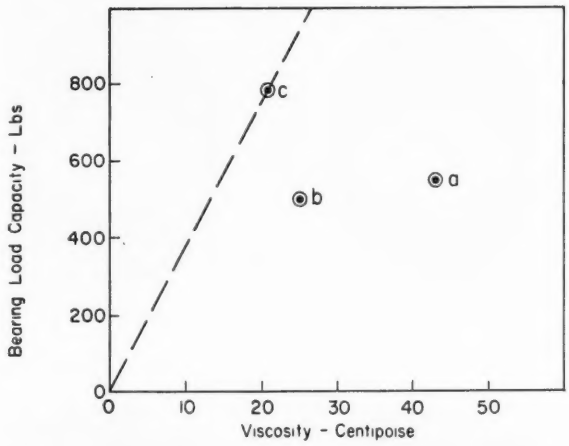

Fig. 6. Theoretical bearing load capacity compared to operating conditions. For load conditions a, b, and c.

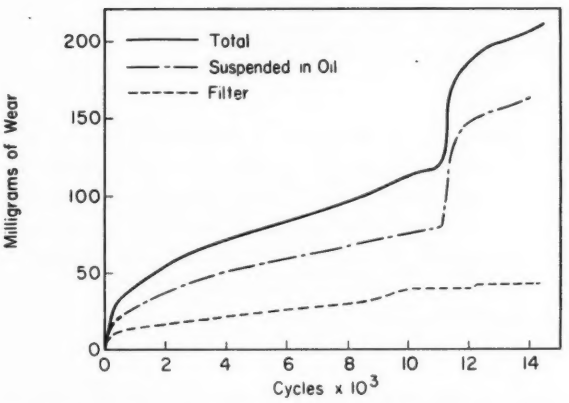

Fig. 7. Measured bearing wear—Unit No. 1. Load condition a, babbitt bearing, paraffinic oil.

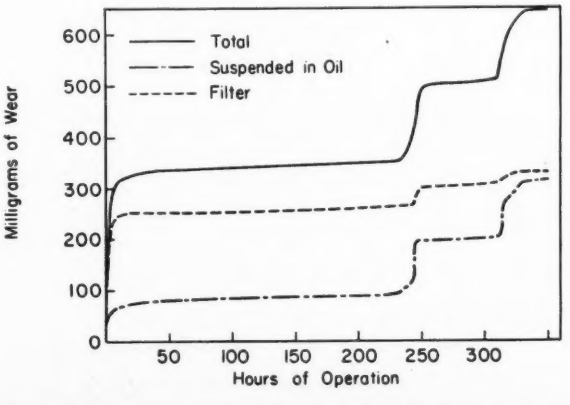

Fig. 8. Measured bearing wear—Unit No. 2. Load condition b, babbitt bearing, paraffinic oil.

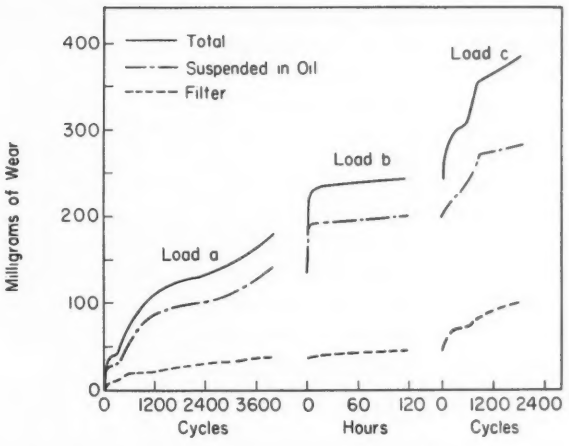

Fig. 9. Measured bearing wear—Unit No. 3. Load conditions a, b, and c in sequence; babbitt bearing, naphthenic oil.

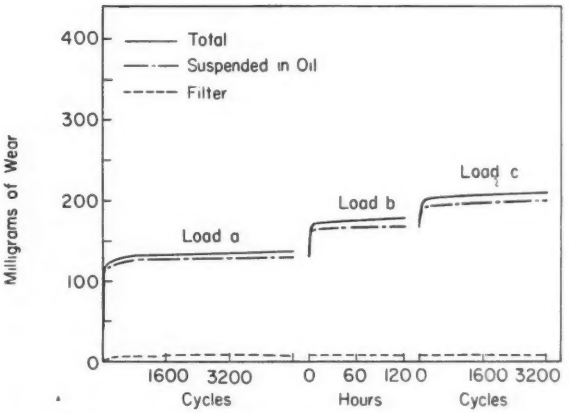

Fig. 10. Measured bearing wear—Unit No. 4. Load conditions a, b, and c in sequence; copper-lead bearing, naphthenic oil.

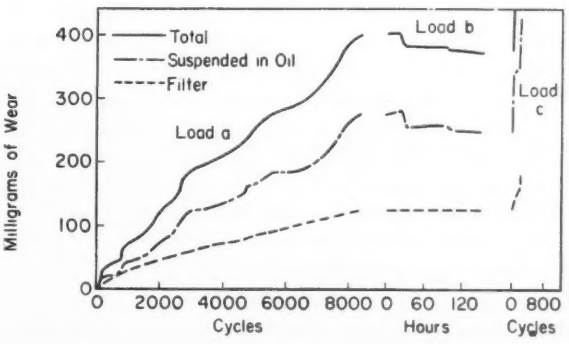

Fig. 11. Measured bearing wear—Unit No. 5. Load conditions a, b, and c in sequence; babbitt bearing, naphthenic oil.

In two tests of this design, condition *c did* prove detrimental. Fig. 9 and Fig. 11 show this condition as the third part of test, with severe wear occurring in both tests. Condition *b* causes low wear, but condition *a* results in an unexpected high wear rate.

If the refrigerant separates from the oil and enters the lube pump, the viscosity estimate for condition *a* is too high. This low viscosity in the bearing aggravates the wear on starting and decreases the load capacity during running. In comparing Fig. 9 with Fig. 10, it is seen that, for this machine, the copper-lead bearing is much more wear-resistant than the babbitt under the cyclic load conditions *a* and *c*.

Note that the babbitt produced many more large particles (greater than 10 microns) than the copper load, as shown by higher filter accumulation. Fig. 11 presents the results of an identical babbitt bearing test which confirms the results of Fig. 9.

The fact that babbitt tended to produce larger wear particles was borne out in the particle size tests conducted in the settling column (Fig. 14). The greatest proportion of babbitt particles in suspension was found to be about 6-8 microns, while copper lead particles were mostly 3-5 microns in diameter.

The first two wear curves, Fig. 7 and Fig. 8, are the first design tested. These machines had grooved babbitt bearings, and an internal lube pump of relatively low capacity.

Fig. 7 shows what happened to one of these machines run under load condition *a* continuously. The same character of wear is observed as in Fig. 9 and Fig. 11, for this load condition. The abrupt rise in the wear rate at 11,000 cycles in Fig. 7 signalled an impending failure in this machine, and the test was stopped. A photograph of these bearings is shown in Fig. 12, illustrating that they were in distress, but not completely failed.

Fig. 8 gives the wear test results for the same configuration under load condition *b*. Each step in the curve corresponds to the imposition of a higher bearing load. These bearings were in trouble from the start, as evidenced by the extremely high initial wear rate. At the time this unit was started, a thermocouple on the back of one bearing showed a temperature of 250F. This unit was allowed to run 350 hours despite the abundance of large particles in the filter, especially after the load change at 240 hours. Observation of these bearings (Fig. 13) proved that the radioactive wear detection method would predict failure.

It is noted that this unit was the only one to exhibit high initial wear. The results of the copper-lead bearing test shown in Fig. 10 are similar at the start, but with only half as much wear. The filter count of large particles was never high with the copper-lead bearing.

CONCLUSIONS

1. In this particular compressor design, copper-lead bearing materials proved superior to tin-base babbitt in wear resistance.

Fig. 12. Bearings after test in Unit No. 1 (See Fig. 7). Bottom bearing at left, top bearing at right.

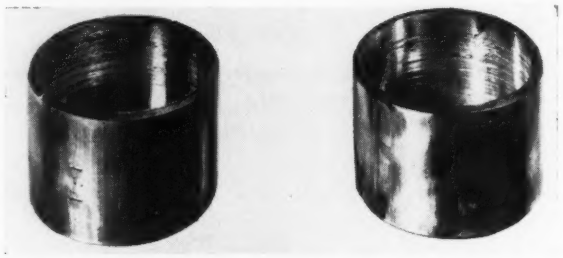

Fig. 13. Bearings after test in unit No. 2 (See Fig. 8). Top bearing at left, bottom bearing at right.

2. Estimates of lubricant viscosities existing in hermetically sealed refrigeration compressors cannot be accurately made from equilibrium dilution curves. In particular, transient conditions are unpredictable, even when temperature and pressure is known, because of the unknown effects of time and agitation.

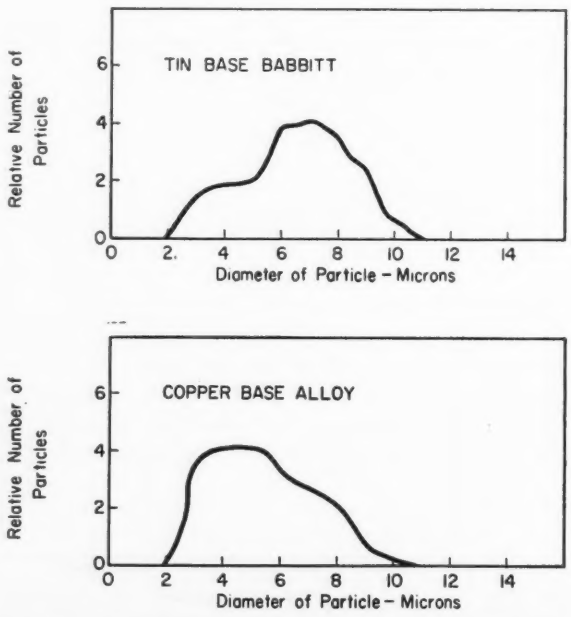

Fig. 14. Size distribution of wear particles—(top), Tin base babbitt; (bottom), Copper base alloy.

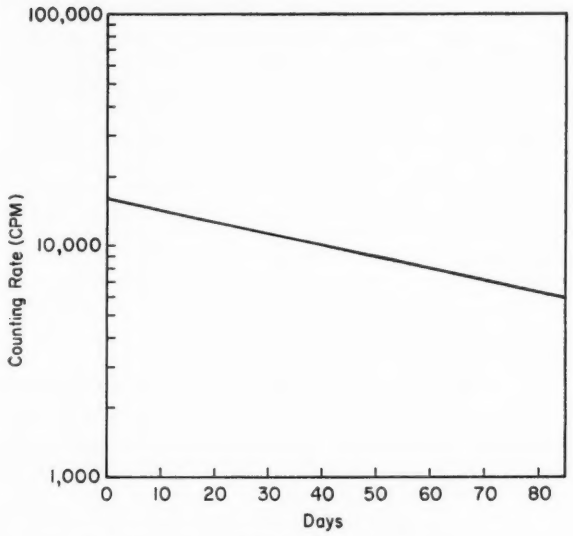

Fig. 15. Typical radioactivity decay curve for babbitt.

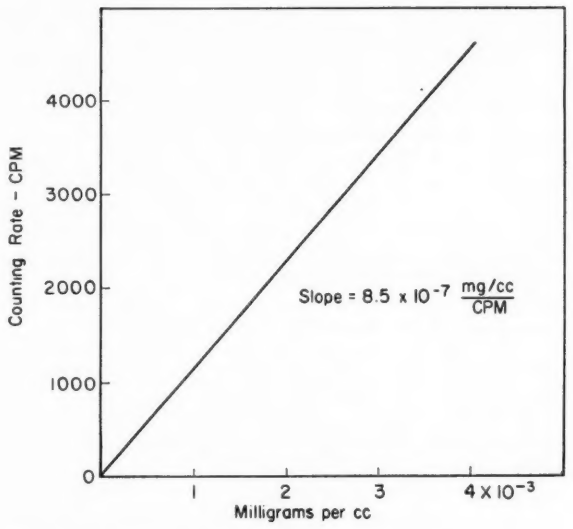

Fig. 16. Typical calibration curve.

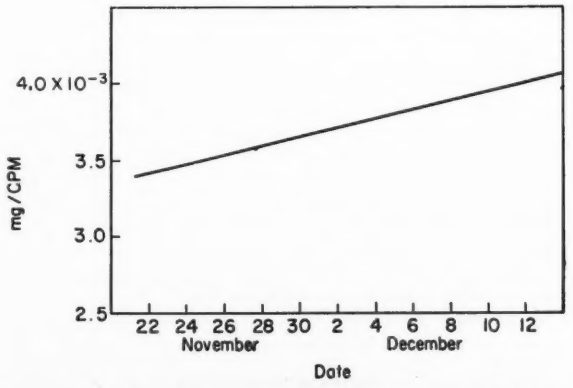

Fig. 17. Typical complete system calibration curve. Corrected for half-life decay.

3. Radioactive wear measuring techniques are excellent tools in the evaluation of this type of machinery, where a closed system is present, and the equipment to be tested is of moderate size.
4. With adequate attention given to the flow path, no difficulty with negative wear rates will be experienced. The only time this problem arose in these tests was in one case where the wear particles were so small that they were gas-borne through the compressor into the condenser, expansion valve, and evaporator. This migration of wear particles was determined by a radiation survey of the entire refrigeration system.
5. Safety is not a major problem in using radioactive tracer techniques if adequate planning is employed before undertaking the work.

APPENDIX

Activity Calculations

Calculation of Minimum Activity

From previous radioactive tests using scintillation detectors, it was found necessary to have at least an activity of 0.01 microcuries (μc) per quart of radioactive solution for good detection sensitivity. This minimum activity depends upon the minimum amount of wear to be measured. In this study it was estimated that the minimum amount of detectable wear would correspond to wear of 0.00001 inch on the inside diameter of two 1.253 inches babbitt bearings. This corresponds to approximately 0.010 gms of uniform bearing wear. Since this wear is distributed throughout four quarts of oil, it is necessary to have at least 0.04 microcuries of radioactive material in the oil.

The specific activity (s) necessary for detection of the minimum amount of wear is:

$$s = \frac{0.04\ \mu c}{1 \times 10^{-2}\ gm} = 4\ \mu c/gm$$

Therefore, it is necessary to have 4 μc of radioactivity per gram of babbitt bearing worn from the surface. This is true only if the bearing is manufactured of one element, but in this particular problem several elements are present in the bearing material.

Calculating Activity for Tin Base Babbitt Bearing

From a consideration of the relative amounts of the different elements in the babbitt and their radioactive half-life, antimony-124 was chosen for the trace isotope. This radioisotope has a half-life of 60 days, which would allow a test period of at least two months before the activity becomes too low for good sensitivity in detecting the wear particles.

The saturation activity (S) of any irradiated material is given by:

$$S = 1.63 \times 10^{-8}\ \frac{\sigma\ f\ F}{A}\ mc/gm$$

where σ = isotopic cross-section in barns for the neutron energy used.
F = neutron flux in neutrons/cm^2-sec.
f = fractional relative abundance of the target isotope.
A = atomic weight of target isotope.

For a neutron flux of 3×10^{12} neutrons/cm^2-sec., the "saturation activity" for Antimony-124 becomes:

$$S = 580\ mc/gm$$

Since seven per cent of the babbitt material is antimony, the minimum detectable wear would be 7×10^{-4} gms of antimony. Of this amount 43 per cent is the target isotope An-

timony-123 (Sb^{123}) or 3.11×10^{-4} gm. Therefore, the specific activity (s) necessary to detect the minimum amount of wear for this material now becomes:

$$s = \frac{0.04\ \mu c}{3.11 \times 10^{-4}\ gm} = 128\ \mu c/gm\ \text{of}\ Sb^{123}$$

The next step is to calculate the build up factor which is necessary to determine the irradiation time.

$$\text{Build up factor} = \frac{\text{minimum specific activity } (s)}{\text{saturation activity } (S)}$$

$$= \frac{128\ \mu c/gm}{580 \times 10^{3}\ \mu c/gm} = 2.2 \times 10^{-4}$$

The irradiation time necessary to obtain this activity is given by "Nomogram for Radioisotope Buildup and Decay" (6) and corresponds to about 20 hours of neutron bombardment with a flux of 3×10^{12} neutrons/cm^2-sec. However, to increase the sensitivity of our measurements, the tin base babbitt bearings were irradiated for five days at the same neutron flux. This gave an activity of 10 mc of Antimony-124.

The total activity for the bearings was also calculated by adding up the activity of the other components of the bearing material. This information was necessary to estimate the radiation hazard which would be present when the bearings were assembled in the compressor.

Calibration of Detection System

To calibrate the system it is first necessary to find the rate at which the activity of the bearing is decaying, and second, the relationship between the observed counting rate and the amount of radioactive material distributed in the oil.

A known amount of the babbitt material was irradiated at the same time as the bearings and in the same neutron flux. This babbitt sample was dissolved with a few drops of hydrochloric acid. This solution was diluted with 10 ml of water to become our stock solution. This solution was used to determine the decay curve for the babbitt as well as the calibration for the system. For this test, all of the radioisotopes except Antimony-124 have a short half-life and are decayed to a very low level within a few days. Therefore, the decay curve, as shown in Fig. 15, shows a half-life of 60 days and corresponds to the decay curve for Antimony-124.

For the counting chamber one ml of the stock solution was mixed with 99 ml of water and was used for the calibration solution. This solution was contained in a duplicate chamber so that the counting geometry corresponds to the wear detection chamber. The remainder of the stock solution, nine ml, was used for the filter calibration.

The calibration curve of the observed counting rate as a function of the concentration for the chamber is shown in Fig. 16 and is only accurate for the day it was taken. To extend the calibration over the period of the entire test, the results of the decay curve Fig. 15 must be combined with the calibration curve in Fig. 16. The final calibration curve covering the entire test is shown in Fig. 17. The amount of wear in the system at any time was found by multiplying the observed counting rate obtained at that time by the calibration factor for that time.

Counting Statistics

Radiation is emitted from a radioactive source in a random way causing a fluctuation in counting rate.

The probable error in counting rate equals $0.624\sqrt{N}$, where N equals the observed counting rate. Throughout this test the maximum counting rate recorded was 180,000 counts per minute and the probable error at this counting rate equals 284 counts per minute.

The statistical error at this counting rate becomes:

$$284\ CPM \times 4 \times 10^{-3}\ mg/CPM = 1.1\ mg$$

This indicates that the maximum error in the amount of measured wear due to counting statistics is approximately $\pm$ 1.1 mg.

BIBLIOGRAPHY

1. Little, J. L., "Viscosity of Lubricating Oil-Freon-22 Mixtures," *Refrig. Eng.*, Nov., 1952.
2. Bosworth, C. M., "Predicting the Behavior of Oils in Refrigeration Systems," *Refrig. Eng.*, June, 1952.
3. Albright, L. F. and Mandelbaum, A. S., "Solubility and Viscosity Characteristics of Mixtures of Lubricating Oils and Freon-13 or -115," *Refrig. Eng.*, v 64, n 10, 1956.
4. Walker, W. O., "Behavior of Refrigerant Oils and Genetron 141," Paper before ASRE, 1956.
5. DuBois, G. B., et al, "Experimental Investigation of Eccentricity Ratio, Friction, and Oil Flow of Long and Short Journal Bearings with Load Number Charts," NACA Technical Note 3491, Sept., 1955.
6. *Nucleonics*, v 4, April 1954.

COMMENTS by E. O. Forster and E. H. Okrent

The authors are to be complimented for the fine work they have done. It is certainly interesting to learn that radioactive tracer techniques can be used in the study of bearing wear in closed systems.

As in most bearing studies, one has to worry about the effect of misalignment on the observed wear rates. It has been pointed out at several occasions that a slight misalignment can cause significantly more wear than all other causes of wear taken together. It would be desirable to learn whether precautions were taken in this case to avoid misalignment, if any, or misalignment was ruled out as a cause of wear.

The conclusion reached by the authors that babbitt bearings are more prone to give high wear rates than copper lead bearings is in agreement with past experience that in a noncorrosive environment Cu-Pb bearings would give better service because of the better fatigue life as compared to babbitt bearings. From the examination of the experiments, another question arises. It is well known that the most abundant γ-rays given off by antimony have an energy of 0.61 mev which is about half the energy of those given off by the zinc isotope—namely, 1.1 mev. The lower the energy of a gamma ray, the higher will be the scattering and unless the counting equipment is capable to discriminate between those scattered γ-rays and the original ones, it will be difficult, if not impossible, to arrive at any valid conclusion. This effect of scattered radiation has to be taken into consideration because the radiation given off by two quite different isotopes is compared. The authors do not indicate what steps they have taken to compensate or correct for this effect of scattered γ-rays. They also have not indicated what type of counting equipment they have used. If anybody would be interested to repeat their experiments, he would have to know what steps were taken to insure the desired high voltage stability and what degree of linearity was achieved with their amplifier. The width of the energy band used in making the counts would also be of interest. All these details should be made available to the interested reader to further increase the value of this contribution.

Finally, it would be interesting to know whether the authors attempted a statistical analysis of their results to see how many runs or measurements have to be made in order to establish a definite trend. Wear processes and failures caused by wear are statistical processes and the prediction of their occurrence has to be based on statistical methods. Undoubtedly it should be possible, based on such statistical methods, to predict incipient failure in a given bearing arrangement under a given set of conditions. The technique used by the authors is well suited for the study of wear but it does not eliminate the need for statistics in predicting failure.

The ideas advanced in this paper certainly open up an interesting field for radioactive tracer studies.

AUTHOR'S CLOSURE

Our thanks are due to Messrs. Forster and Okrent for the effort they expended in preparing their discussion.

No attempt was made to measure alignment following machining since the delicacy of the measurement would have required considerable time and therefore considerable radiation exposure.

However, possible misalignment of the shaft in these bearings was calculated, based on the manufacturing tolerance and bending of the shaft. The order of magnitude of possible misalignment was similar to the minimum film thickness. Little evidence was found in the tests that serious misalignment occurred, however, leading us to believe that the allowed machining tolerances were not fully used.

One bottom bearing (Fig. 13) shows babbitt pushed out of the bore most of the way around as possible evidence of misalignment, but this would more logically occur after the gross damage to the bore.

We do not believe that the wear of hydrodynamic bearings must be necessarily evaluated statistically, as are rolling element bearings. The condition of operation where wear occurs is either: a) on starting and stopping, and b) under overloads while running, or c) under severe misalignment. Overloads can be detected on the basis of very few tests—either the bearings have sufficient load capacity or they do not. Start-stop conditions, where there is momentary metal-to-metal contact, may require statistical evaluation. We did not attempt a statistical analysis of this system because:

1) Lack of sufficient samples.
2) The test series was intended to compare the performance of different bearing systems, rather than completely evaluate a final configuration.

Our conclusion that copper-lead bearings were superior to babbitt is specifically limited to this particular machine. It is interesting that Messrs. Forster and Okrent have reached the same conclusion in other applications, but we, of course, cannot substantiate it any further within the scope of the paper.

The questions raised concerning energy levels, scattering, and width of energy bands did not appear to apply to this application. At length we realized that the discussors were under the impression that the two different bearing materials were being evaluated simultaneously in the same system. This was not so. In any given test unit both radioactive bearings were of the same material. Since we used individual calibrations for each test, as described in the Appendix, we were not concerned with the differences in scattering, energy levels, or width of energy bands between the isotopes. Different materials could have been evaluated simultaneously, of course, subject to the complications described by the discussors.

As for the equipment used, the primary element was a G.E. Scintillation Detector containing a 5819 photomultiplier tube (sodium iodide crystal). The count rate meter was manufactured by Tracerlab, Inc. High voltage supply to the detector changed 0.3 volt for a 1% line voltage change. The tube was operated near the center of a 925 to 1025 volt linear plateau over which constant output was indicated regardless of voltage supply.

Our thanks are due to Mr. Harvey D. Briggs of the General Electric Company, General Engineering Laboratory, Engineering Physics and Analysis Laboratory. He was directly responsible for actual conduct of the radiation measurements, and the activity calculations given in the Appendix. His assistance in answering the above instrumentation details is also greatly appreciated.

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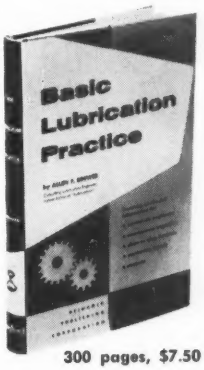

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Effect of Solid Additives on Fluid Lubricants

by Harold L. Herzig

Climax Molybdenum Company of Michigan, Detroit, Michigan

The effect of solid additives in fluid lubricants on the coefficient of friction is attributed, in this article, to the ability of additives to smooth the surface of a bearing during operation and to the shear strength of the additives. By proposed empirical formulation, the effects of particle dimension and concentration of the additive and the effect of error in geometry of the bearing are quantitatively described. The analysis indicates that comparisons between various lubricants in any test which does not evaluate the role of error in geometry of the test bearing are apt to be misleading and that very small differences in error in geometry, quite immeasurable by ordinary methods, have a pronounced effect on the position of the practical friction curve. Data from a foil-bearing experiment supports the formulation and confirms the potential of molybdenum disulfide as an additive to fluid lubricants.

The increasing use of molybdenum disulfide as an additive to fluid lubricants gave rise to speculation concerning the role of solid additives in fluid lubricants. In this speculation, it appeared that the classical relationships developed by previous investigators for the hydrodynamic range of lubrication might, with certain modification, be extended to cover the situation when solid additives are present. Toward the end of such an extension of theory, a project directed at a more complete understanding of the role of solid additives over the entire range of lubrication was undertaken.

Since the prime objective in lubrication is to reduce friction, this project began with consideration of the f, ZN/P relationship for hydrodynamic lubrication which states that for theoretically true and smooth surfaces the logarithm of the coefficient of friction varies directly with the logarithm of the parameter ZN/P where Z is the viscosity of the lubricant, N, the speed, and P, the load, all in appropriate units.

In the so-called hydrodynamic region of lubrication, Michell (1) reasoned theoretically that the deviation of the measured coefficient of friction from the coefficient predicted by the theoretical f, ZN/P relationship could be accounted for by the surface roughness or the "error in geometry" of a practical surface, as compared to a theoretically true and smooth surface. It was shown experimentally by Lewis (2) that smoothing the surface of a practical bearing caused a reduction in the coefficient of friction for all values of ZN/P, shifting the entire f, ZN/P curve downward and to the left. More recently, Rylander (3) commented on the role of surface finish. These observations constitute an avenue of attack for studying the role of solid additives to liquid lubricants.

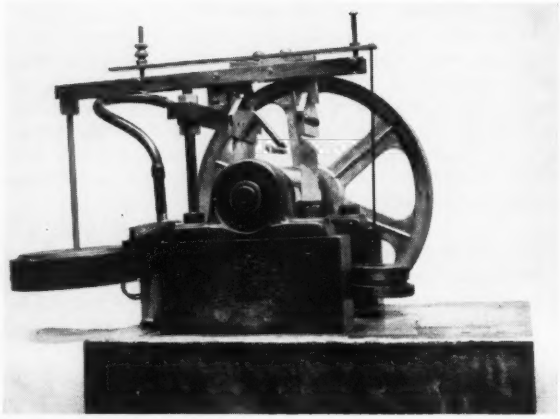

Fig. 1. Foil-bearing machine.

An inert and insoluble solid additive has two attributes that can affect the coefficient of friction of a bearing: first, its volume and second, its shear strength. The shear strength of the additive could be effective in changing the coefficient of friction of a bearing only when shear of the additive occurs, but the volume of the additive could be effective in two ways: by filming the surface, thereby smoothing the bearing, and by occupying space that would normally be occupied by the liquid lubricant.

Since a change in the error in geometry affects performance of a practical bearing, and since an additive might affect the error in geometry, the formulation of a role for solid additives to fluid lubricants requires that a way be found to evaluate this factor for the particular friction machine used and the operating conditions employed.

THE FOIL-BEARING FRICTION MACHINE

The foil-bearing friction machine, as conceived by

H. Blok (4) (Fig. 1), was deemed to be most readily adaptable to the requirements of the proposed experiments and was used to obtain the experimental data. In his work, Blok calculated the following two equations for his foil-bearing machine and established their validity with experimental data:

$$f = 2.05(ZN/P)^{1/3} + 6.3(ZN/P)^{2/3} \quad [1]$$

$$h = 4.78R(ZN/P)^{2/3} \quad [2]$$

where f = the coefficient of friction

Z = viscosity of oil in reyns
P = pressure in lb/sq. in. of projection area of the bearing
h = oil film thickness in inches
R = radius of journal in inches
N = revolutions/sec. of journal

These equations apply to theoretically true and smooth bearing surface conditions. Equation [1] was used to calculate the theoretical f, ZN/P curve, Fig. 2, in which the values are plotted log-log. Equation [2] was used to calculate the h values for the scale at the top of Fig. 2.

MODIFICATION OF THE F, ZN/P RELATIONSHIP FOR ERROR IN GEOMETRY

For calculating and plotting a practical f'_c, ZN/P curve, where the error in geometry must be considered, the following empirical Equation [3] was conceived and developed by the author to relate the coefficient of friction of a practical bearing, containing "error" E, to the coefficient of friction of an errorless theoretical bearing:

$$f_c' = \frac{f}{1 - E/h} \quad [3]$$

where f'_c = calculated coefficient of friction for a practical bearing

f = calculated coefficient of friction for a theoretical bearing calculated from Equation [1]
h = calculated film thickness from Equation [2]
E = error in geometry in inches

The meaning of the terms E and h are as follows: Retaining the teaching of Blok for errorless surfaces but providing for the average deviation from perfect geometry in a practical bearing, the factor E in this concept comprises all the volume occurring between the bearing surfaces under operating conditions which is attributable to surface irregularity, distortion, nonconformance or misalignment. E is measured in inches as such a volume divided by the bearing area. The term h in this concept (consistent with Blok) is the total volume between the bearing surfaces divided by the bearing area. The parameter E/h for the practical bearing is actually a volume ratio and, indeed, as E approaches zero, the parameter disappears.

For a plot of this equation, in Fig. 3, E was assumed to be 0.0001 inch. For various values of ZN/P, f and h were calculated from Equations [1] and [2]. Using Equation [3], f'_c was calculated and plotted log-log against ZN/P.

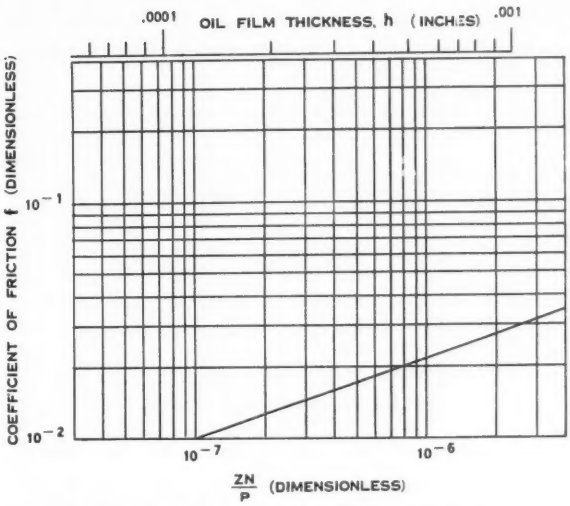

Fig. 2. Theoretical f, ZN/P curve and oil film thickness scale.

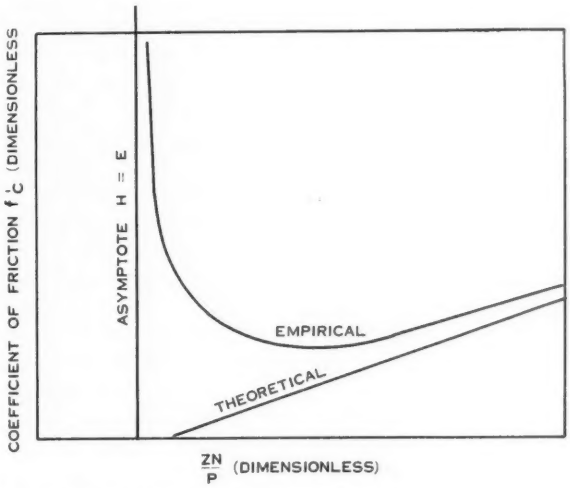

Fig. 3. Calculated f'c, ZN/P curve for foil bearing.

The curve has the following properties: It is asymptotic to the f, ZN/P line and to a line at $h = E$. This $h = E$ asymptote is drawn at $h = 0.0001$ inch in Fig. 3. The curve retains the same shape but shifts to the left or right along the f, ZN/P line as E is assumed smaller or larger. Its relation to the f, ZN/P and $h = E$ lines remains constant. Since any value of E produces a curve of the same shape and in the same relation to the f, ZN/P and $h = E$ lines, the family of curves for a variable E can be represented by a single curve on transparent paper which can be moved to match any experimental curve. If, in making such a match, the theoretical f, ZN/P lines of an experimental and the empirical curve are kept coincident and one chart is moved until the best conformance of the two curves is obtained, the $h = E$ asymptote of the calculated em-

TABLE 1. DATA FROM FOIL-BEARING MACHINE

	W	w	p	f'_e	ZN/P	RPM	f	h	CALCULATED E
1.	5	.112	4.851	.0231	1.92×10^{-7}	9.6	.0121	0.000188	0.0000985
2.	5	.135	4.820	.0280	1.78×10^{-7}	8.8	.0117	.000177	.0001030
3.	5	.206	4.725	.0436	1.00×10^{-7}	4.85	.0097	.000121	.0000941

pirical curve will point to the value of E for the test bearing on the h scale of the experimental curve.

EVALUATING ERROR IN GEOMETRY OF A BEARING USING OIL ONLY

An experimental curve from the foil-bearing machine, using oil only as a lubricant, is drawn in Fig. 4. If an empirical curve, drawn from Equation [3], is superimposed on this experimental curve, it will be seen that in the hydrodynamic range the match is excellent and that by the proposed matching procedure, the error in geometry during that experiment is indicated as 0.00009 inch by the asymptote of the calculated empirical curve.

Solution of Equation [3], using experimentally determined values of the coefficient of friction* for three critical points on the curve in Fig. 4 give calculated values for E. The data for these points are given in Table 1.

By averaging these values of E, the error is calculated to be 0.0000955 inch.

It is believed that this formulation, which provides a method of evaluating error in geometry of a bearing under operation, is a key to the reconciliation of the long-established theory of hydrodynamic lubrication and the higher friction values obtained experimentally at low values of ZN/P.

THE SITUATION WITH ADDITIVES

Having thus determined a way in which the error in geometry, E, can be evaluated, additional experimental curves were obtained for oil alone and for oil containing various percentages of additives. These curves obtained experimentally, as explained in Appendix 1, are shown in Figs. 5 to 9.

Applying the method of matching curves to determine the error in geometry** for these additional curves reveals that while the matching is excellent for the curves employing oil only, the best matching of curves when a solid additive is present requires that the theoretical f, ZN/P lines be parallel rather than coincident. It was postulated that this deviation is significant and that it can be accounted for by the volume of the suspended solid additive present and the particle size of that additive. The possibility that Equation [3] can be modified to account for the effect of suspended additive and for the deviation of the experimental curve from the calculated curve at low values of ZN/P is, therefore, carefully examined.

EMPIRICAL EQUATION WHEN SOLID ADDITIVES ARE PRESENT

If all of the additive is used up in filming the surface, no suspended additive will remain and the result will simply be a change in the error of geometry. For this condition, Equation [3] would still apply. But some of the additive will always remain suspended in the lubricant, and it is purposed that the presence of the solid, suspended additive in a liquid lubricant, will require modifying Equation [3], due to the volume and dimensions of the suspended particles. Such modification must bring about better conformance between the empirical and experimental curves and must justify the procedure of matching curves on the basis of parallel, rather than coincident theoretical f, ZN/P lines.

In Equation [3], $f'_e = f/1 - E/h$, or in the form $f'_e = hf/h - E$, the only factor that could be affected by a suspended additive is the term h. Assuming a modifier k, the general equation would become:

$$f'_e = \frac{khf}{kh - E} = \frac{f}{1 - \frac{E}{kh}} \qquad [4]$$

(where k must equal one if there is no suspended additive).

The meaning of the term k is based on the following hypothesis. The presence of a solid suspended additive in a liquid lubricant will divide the oil film into a number of component films, and it is the thickness of one of these component films that is effective in determining the coefficient of friction.

For an evaluation of k, one assumes that the additive particles have an average minimum dimension α* and are present in an amount v which is expressed as the ratio of the volume of the particles to the total lubricant volume (solid plus liquid). Then, h/α = the maximum number of particles of a thickness α that could be contained in a column of lubricant of a thickness h and hv/α is the actual number of

* Experimental procedures and details of determination of f_e' are given in Appendix 1.

** The values noted on the h scale in these figures indicate the asymptote values for some of the curves.

* The use of average minimum dimension, rather than particle diameter, is required since it is assumed that the suspended particles will orient themselves so that their minimum dimension is perpendicular to the direction of flow of the lubricant.

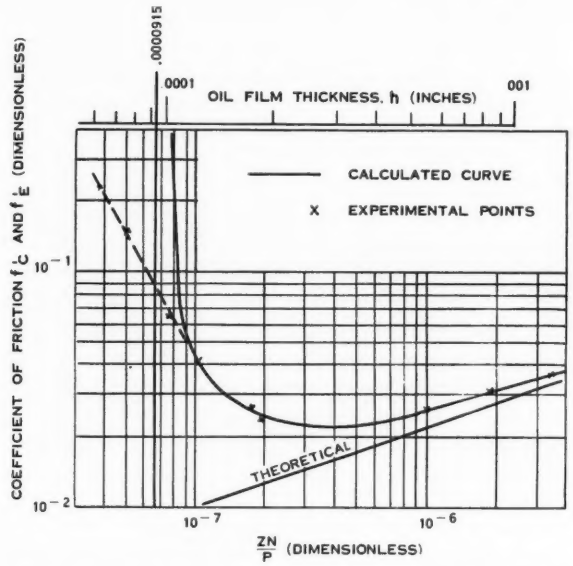

Fig. 4. Deviation of experimental curve for oil from calculated curve.

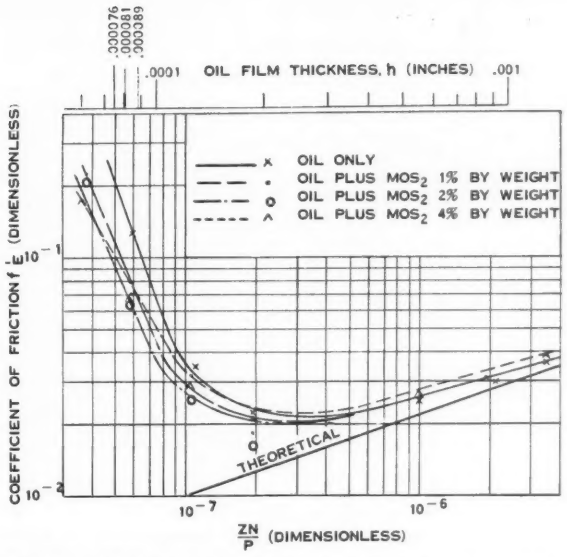

Fig. 5. f'e, ZN/P curves for foil bearing with various amounts of molybdenum disulfide added to oil.

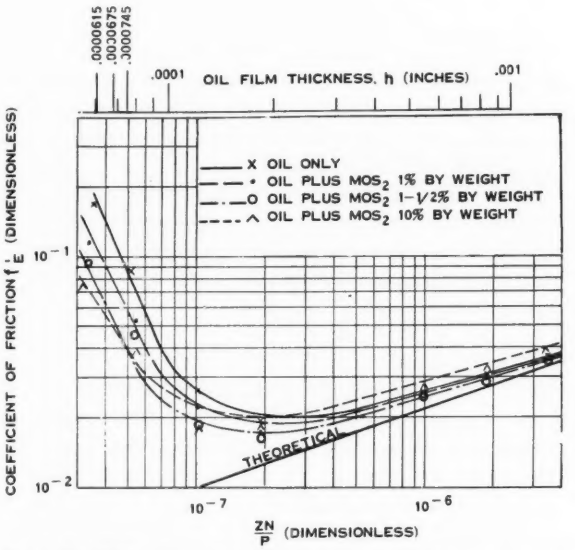

Fig. 6. f'e, ZN/P curves for foil bearing with various amounts of molybdenum disulfide added to oil.

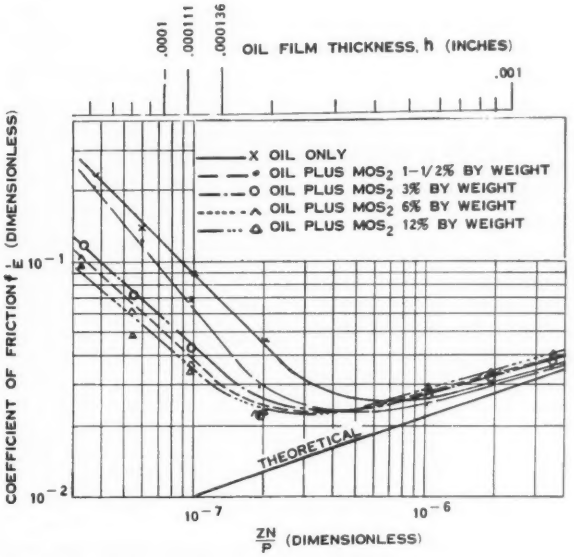

Fig. 7. f'e, ZN/P curves for foil bearing with various amounts of molybdenum disulfide added to oil.

particles of additive in that column. Then, $hv/\alpha + 1$ would be the number of spaces or oil films into which the column would be divided by hv/α particles. The amount of oil in the column would be $h - hv$ which, if divided by the number of spaces, gives the average thickness of the oil films between particles, thus:

$$kh = \frac{h - hv}{\frac{hv + 1}{\alpha}} = \frac{\alpha h(1 - v)}{\alpha + hv} \qquad [5]$$

or

$$k = \frac{\alpha(1 - v)}{\alpha + hv} \qquad [6]$$

Substituting this value of k in Equation [4], the empirical equation for the calculated coefficient of friction when an additive is present becomes:

$$f_c' = \frac{f}{1 - \frac{E}{h}} = \frac{f}{1 - \frac{E}{\frac{h\alpha(1 - v)}{\alpha + hv}}} = \frac{f}{1 - \frac{E(\alpha + hv)}{h\alpha(1 - v)}} \qquad [7]$$

This general empirical equation is asymptotic to a line parallel to the theoretical f, ZN/P line and its vertical asymptote occurs at $h = E/k_a$. If the point at which this asympototte crosses, the h scale is designated as E', the relation of E to E' is expressed:

$$E = E'k_a \qquad [8]$$

k_a being the value of k at the asymptote.

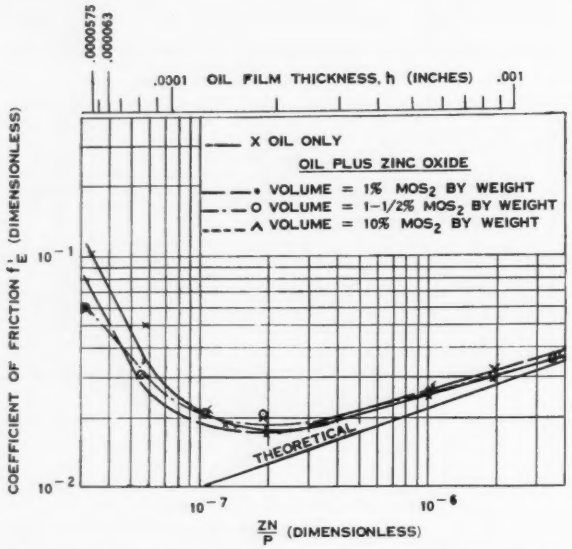

Fig. 8. f'_e, ZN/P curves for foil bearing with various amounts of zinc oxide added to oil.

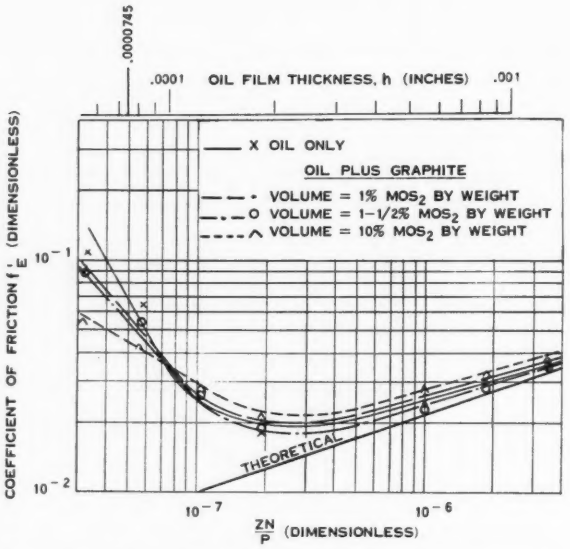
.0000745
.0001 OIL FILM THICKNESS, h (INCHES) .001
X OIL ONLY
OIL PLUS GRAPHITE
VOLUME = 1% MOS2 BY WEIGHT
VOLUME = 1-1/2% MOS2 BY WEIGHT
VOLUME = 10% MOS2 BY WEIGHT
COEFFICIENT OF FRICTION f'e (DIMENSIONLESS)
THEORETICAL
ZN/P (DIMENSIONLESS)

Fig. 9. f'_e, ZN/P curves for foil bearing with various amounts of graphite added to oil.

A substitution of experimental values in Equation [7] will reveal that this modified empirical equation accounts for the deviations between the oil only and oil-additive curves and permits calculation of the coefficient of friction in the hydrodynamic range when an inert solid additive of known minimum dimension is present in a known amount and when an error in geometry is assumed.

The mathematical relationship of this empirical equation for lubricants with additives to the equation for oil alone is clearer when, by using the relation $E = E'k_a$, both equations are put in the same form.

$$f_e' = \frac{f}{1 - \dfrac{E}{\dfrac{h\alpha(1-v)}{\alpha + hv}}} \qquad [9]$$

Using the relationship $E = E'k_a$,

$$k_a = \frac{\alpha(1-v)}{\alpha + E'v}$$

and the knowledge that $h = E'$ at the asymptote, we obtain this form:

$$f_e' = \frac{f}{1 - \dfrac{\dfrac{E'\alpha(1-v)}{\alpha + E'v}}{\dfrac{h\alpha(1-v)}{\alpha + hv}}}$$

simplifying this, becomes:

$$f_e' = \frac{fh\left(1 + \dfrac{E'v}{\alpha}\right)}{h - E'}$$

If the term $1 + E'v/\alpha$ is expressed as B, the empirical equation with or without additives for the calculation of f'_e becomes:

$$f_e' = \frac{fh}{h - E'} B \qquad [10]$$

B contains the factors "α" and "v', but it must be remembered that E' is the error only when no additive is present. In the presence of an additive, E is determined by $E = E'k_a$.

The formulation shows that the term B is the necessary vertical displacement of the theoretical f, ZN/P line which is required when matching an empirical curve with an experimental curve for a lubricant containing solid additives.

The value of the vertical displacement may be measured on the f'_e scale as the ratio of the displaced f, ZN/P line of the empirical curve to the f, ZN/P line of the experimental curve. Using such a value of B and the value of E' obtained by matched curves, the equation can be solved and the effective values of E and α* are determinable.

Calculation of f'_e according to Equation [10], for all points on all experimental curves within the hydrodynamic region, gave values with an average plus error of 5 per cent and an average minus error of 4.5 per cent when compared with the experimental values of f'_e for the same points.

It was concluded that the equation described the situation within the limits of experimental error and that significance can be attached to the role of error in geometry and to the effect of the solid additive's minimum dimension and concentration as prescribed in the formulation.

SOLID ADDITIVES IN THE BOUNDARY RANGE

While the empirical formulation quantitatively accounts for the deviation of the practical friction curve from the theoretical curve at high ZN/P values,

* See Appendix 2.

and while it describes the minimum in the friction curve and predicts the rising friction values at lower ZN/P, a point is reached where it is obvious that new mechanisms control and the formula no longer applies. The fact that experimental friction values are lower than those predicted by the equation may be ascribed to a lowering of the error in geometry and/or the phenomena of solid shear. Even under the light loads and short times employed in the experiments with the foil-bearing machine, there is evidence that both are taking place. It should already be obvious that if for any reason the error becomes smaller, for example, through elastic deformation, a lower value of f'_c will be obtained. Such a friction value could be calculated if the change in E was known and if no solid shear was occurring. The mechanism of the effect of the decreasing E undoubtedly occurs to a considerable extent in any bearing and especially in a foil-bearing type experiment. But even if the error in geometry does not change, lower values of the coefficient of friction would result when the approach of the bearing surfaces is so close that solid shear of the metal or the additive takes place. Since the shear strength of the metal or the additive is not infinite, in the case of oil only, the shear strength of the metal and, in the case of additives, the shear strength of the additive determines the limiting value of the coefficient of friction. The extent to which solid shear is taking place determines the friction coefficient, and the lower the shear strength of the solid being sheared, the lower the friction. Therefore, in the boundary range of lubrication, the presence of an additive of low-shear strength inevitably reduces the limiting coefficient of friction whether or not it films on the surface.

CONCLUSIONS

1. The equation $f'_c = f/(1 - E/h)$ represents the coefficient of friction of a practical bearing containing an error in geometry lubricated by a liquid lubricant only at any value of ZN/P. It predicts that if E is constant or becomes constant, f'_c will approach infinity, unless it is limited by some other factor. This other factor is the shear strength of the bearing metal.
2. If the lubricant contains a solid additive, some of the additive may become attached to the surface, thereby changing the value of E. The additive that remains suspended in the lubricant will reduce the volume of liquid lubricant present and separate it into layers, thereby reducing the effective value of h. But, f'_c will still approach infinity, unless it is limited by some other factor. In this case, the other factor is the shear strength of the additive and/or the bearing metal. The general equation in the case of a liquid lubricant containing an additive is:

$$f_c' = \frac{fB}{1 - \frac{E'}{h}}$$

3. Any filming action of an inert and insoluble additive which during operation will smooth the surface of a bearing will act to reduce the coefficient of friction over the entire range of lubrication.
4. Whenever solid shear takes place, the coefficient of friction of that portion of the bearing so affected becomes constant at a value equal to the coefficient of friction produced by the solid being sheared, regardless of whether the solid being sheared is bearing metal or additives, or whether it is attached to the bearing or simply rendered immobile in the lubricant by thin films between the particles.
5. The desirable low-shear strength and ability to reduce error in geometry characteristic of molybdenum disulfide are manifest in this interpretation of the role of additives on bearing behavior.

APPENDIX I

The foil-bearing machine used in these experiments is shown in the accompanying photograph (Fig. 10). The steel journal is 2.3 inches in diameter, and a speed reducer made speeds as low as 1-½ rpm possible. The foil is 0.003 inch × 3 inch shim steel and of sufficient length to connect to the lever system. Oil is pumped from a well onto the journal and allowed to drain back to the well. The lever system, its constants and the equation for determining the experimental coefficient of friction f'_c are shown (Fig. 10).

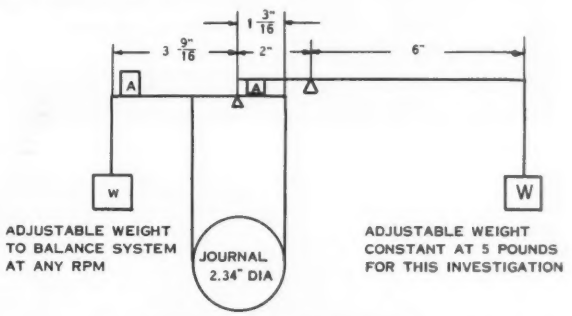

Fig. 10. Sketch of foil-bearing machine.

For this lever system, $f'_c = w/p = w/(W - 4/3w)$, the projected area of the bearing is 7 sq. in., and the viscosity of the oil used 0.0000025 reyns. The foil and journal were surfaced at the beginning of each test with 320 emery cloth, no solvent being used for cleaning. It was necessary to run oil only at the start of each test to determine the original value of E, and the weight W was kept constant at five lbs during the test, ZN/P being changed by changing the speed N. This was necessary as it was found that changing the weight W changed the value of E by changing the strain on the foil. The balancing weight w was sensitive to about 0.002 lb at 0.2 lb being larger for higher values of w.

The procedure for the experimental runs was as follows:

1. Using oil only as the lubricant, with W at five pounds, the balancing weight w was obtained for values of N from 170 rpm to 1-½ rpm.
2. A small percentage of the additive to be investigated was made and the procedure of Step 1 was repeated.
3. Successively higher additions were made to increase the percentage of additive.

Since the volume of additive rather than the percent by weight is the controlling factor, the amounts of graphite and zinc oxide employed were chosen so that they would be equivalent to the volumes of molybdenum disulfide used.

(Cont. on p. 158)

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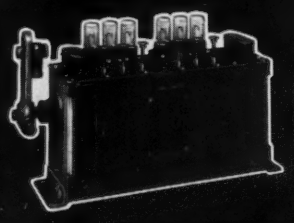

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(Cont. from p. 157)

APPENDIX II

The particle size of the MoS_2 used in these experiments was reported to be between 0.5 and 0.75 microns. Such particle size determinations are based on the assumption that the particles are spherical. The average minimum dimension for the MoS_2, derived from the formulation herein developed, is 0.0000099 in.

Based on a knowledge of the structure of MoS_2 and observation of its physical character, it is a reasonable assumption that the minimum dimension of a MoS_2 plate is in the order of 1/10 the maximum dimensions. On this assumption, it can be shown that the volume of a particle with a minimum dimension of 0.000099 in. is consistent with a nominal spherical particle size of 0.5 to 0.75 micron.

Consideration of the graphite and zinc oxide additions on the same basis could not be made since reliable particle size measurements on these additives were not available. However, in the formulation, the average minimum dimensions derived for graphite were the same for all concentrations of graphite used; whereas, the effective minimum dimension of the zinc oxide appeared to increase tenfold with an increase of concentration from 1 to 10 percent. Presumably, this could be due to the well known tendency of zinc oxide to agglomerate.

BIBLIOGRAPHY

1. Michell, A. G. M., "Lubrication," Blackie and Son, Ltd. London, Appendix 1, 1950, pp. 281–291
2. Lewis, C., "Proceedings at the Special Summer Conference on Friction and Surface Finish," Massachusetts Institute of Technology 1940, pp. 212–213
3. Rylander, H. G., "Effect of Solid Inclusions in Sleeve-Bearing Oil Supply," *Mechanical Engineering* 74 Part 2, 1952, pp. 963–966
4. Blok, H., "Foil Bearing," *Lubrication Engineering*, v. 9, n. 6, pp. 316–320

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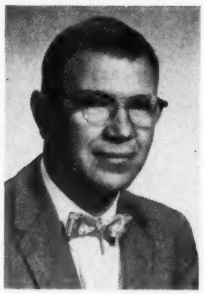


C. M. ALLEN

Preprint 59AM 1A1

1959 Annual Meeting Abstracts

Only those abstracts and photographs available at publication time are included below. A preprint order form appears on page 171.

R. J. BAKER

Preprint 59AM 3A2

EVALUATION OF DRY POWDERED LUBRICANTS AT 1000F IN A MODIFIED SHELL FOUR-BALL WEAR MACHINE, by S. L. Cosgrove, L. B. Sibley, and C. M. Allen, Battelle Memorial Institute, 59AM 1A1.

Friction and wear behavior of selected solid lubricants and wear specimens has been studied in a modified Shell Four-Ball wear machine at 1000F at a sliding speed of 700 feet per minute and an initial Hertzian contact stress of 250,000 psi.

Conventional solid lubricant materials such as lead oxide (litharge), molybdenum disulfide, and graphite were studied. A new dry solid lubricant, metal-free phthalocyanine, was studied and found to be a superior lubricant. Wear specimens of M-1 tool steel and titanium carbide-nickel-molybdenum cermet showed the most promise for high-temperature sliding systems. Initial coefficients of friction less than 0.1 were obtained with combinations of these materials.

Two methods of applying the powdered lubricants were studied. In one the solid lubricant was applied at the beginning of each experiment as a paste in polyisobutylene. The other method consisted of suspending the dry powder in a stream of nitrogen and periodically supplying it to the rubbing surfaces. Under lubricant replenishing conditions and at 1000F, the metal-free phthalocyanine and titanium carbide cermet system showed a constant coefficient of friction (0.04) and very low wear over a 30-minute period. It seems that extended period evaluations and further development of lubricant pretreatment and replenishing techniques are needed before practical lubrication systems can be recommended.

S. J. BARBER

Preprint 59AM 2A2

HIGH-TEMPERATURE FRICTION AND WEAR PROPERTIES OF BONDED SOLID LUBRICANT FILMS CONTAINING LEAD MONOXIDE, by R. L. Johnson and H. E. Sliney, of NASA, Cleveland, Ohio, 59AM 1A4.

A friction, wear, and endurance-life study was made with bonded films of mixed oxides containing lead monoxide (PbO) as the main components. The solid-lubricant films were bonded to low-carbon-steel and stainless steel disks. Hemispherical tipped (3/16-in. rad) M-1 tool-steel riders were run against the coated flat surfaces of disks at a sliding velocity of 430 feet per minute at temperatures up to 1250F. Cast Inconel riders were also used for runs above 100F.

The coatings lubricated over the entire temperature range, but were far more effective from 500F to 1250F

J. W. BARGER

Preprint 59AM 3B1

than at the lower temperatures. Improved lubrication at the higher temperatures was apparently associated with the formation of a glazed wear track on the coated disks.

The endurance life of the coatings in high-load friction test was much better from 500 to 1250F than at lower temperatures. However, the endurance life at room temperature was at least as good as that of a resin-bonded molybdenum disulfide (MoS_2) lubricant film. Friction was somewhat higher at all temperatures than for MoS_2 at room temperature.

Bonded coatings with PbO as the primary component appear promising for use as high-temperature solid-lubricant films. In addition to good lubricating properties at evaluated temperature, these bonded coatings appear to have sufficiently good room-temperature properties for use in applications requiring cycling through a wide temperature range.

E. L. H. BASTIAN

Preprint 59AM 2A3

FIRE RESISTANT HYDRAULIC FLUIDS IN A STEEL MILL, by Leo R. McDonald, Wheeling Steel Corp., Steubenville, Ohio, 59AM 1B1.

There have been three basic types of fire resistant fluids developed for hydraulic applications—the water-glycol fluids, the water-oil emulsion fluids, and the synthetic fluids. These fluids are part of the program to develop a truly fire resistant fluid that will perform satisfactorily at a reasonable cost.

These fluids all have definite limitations, some of which have been determined by the manufacturers. Additional knowledge has been gained through experience obtained in the field.

Such items as suction strainers size, hoses, gasket and seal materials, and rust preventive coatings must be compatible with the fluids. These can vary with the type of fluid selected, and considerable difficulty can be encountered if they are not properly matched.

Some specific problems and experiences are cited to point up the care that must be observed in the selection and use of fire resistant hydraulic fluids.

W. H. BAUER

Preprint 59AM 2B2

SPUR GEAR—HERTZIAN CONTACT TIMES, by E. K. Gatcomb, R. P. Hunnicutt and G. S. Kinney of U. S. Naval Post Graduate School, Monterey, Calif., 59AM 1C1.

The contact time between mating gear teeth is important in the study of the stress gradients developed in high-speed gears and in dynamic lubrication processes where the finite time required for acceleration and viscous flow of lubricant escaping from the contacting area must be considered. Contact times also enter into lubrication processes when the characteristics of a dynamically loaded lubricant film depend on the rate of loading, such as the behavior which has been observed with ultra-rapid loading rates. In this paper, the definition of contact time is based on the half-width of a band of contact. Contact areas for five phases of contact are of special interest, those at (1) the first point of contact, (2) the first point where a single pair of teeth take all the load, (3) the pitch point, (4) the point where more than one pair again share the load, and (5) the last point of contact. Expressions are developed for (a) the contact ratio, (b) the Hertzian contact stress, and (c) the Hertzian contact time for all five phases of contact. These relations apply di-

A. C. BORG

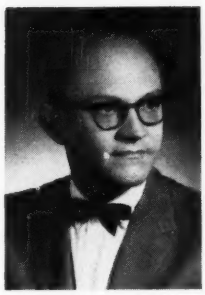
Preprint 59AM 2B2

R. BYRNE

Preprint 59AM 3C1

H. B. CARPENTER

Preprint 59AM 3A4



W. A. GLAESER

Preprint 59AM 5A3

S. L. COSGROVE

Preprint 59AM 1A1

S. M. DARLING

Preprint 59AM 3B3

rectly to gear teeth with involute profiles, without consideration for a modification of the elastically deformed surface due to lubricant action. These expressions may be extended by numerical methods to provide values for gear teeth which show deviation from the ideal involute such as occur when tip relief is provided.

CONDITIONING OF VACUUM PUMP OILS, by G. Topol, S. F. Bowser Co., Hamilton, Ontario, Canada, 59AM 1C2.

Performance of a high vacuum pump depends greatly on the quality of its sealing oils. Special oils with a low vapour pressure are employed to obtain the best results in evacuation. However, during the operation of the vacuum pump, oil is repeatedly being brought into intimate contact with air, or the medium which is pumped. Air, gases, moisture and condensable vapours are thus drawn into the oil and become dissolved or suspended in it. This type of contamination increases the vapour pressure of the oil making the oil ineffective as a sealing medium. Reduction in capacity of the vacuum pump due to oil contamination, together with shut-down time and cost of oil replacement, may become a serious economic factor.

By exposing the oil to vacuum in a chamber attached to the vacuum pump oil reservoir, air, gases and vapours can be removed from the oil. This arrangement maintains the cleanliness and sealing quality of the oil through the continuous removal of contaminants. Laboratory and field tests show a significant improvement in the performance and economy of vacuum pump operation as the result of oil conditioning.

CAM AND TAPPET LUBRICATION IV—RADIOACTIVE STUDY OF SULFUR IN THE E-P FILM, by E. H. Loeser, R. C. Wiquist, S. B. Twiss, Chrysler Corp., Detroit, Mich., 59AM 1C4.

A radioactive tracer, sulfur-35, synthesized into zinc dialkyl dithiophosphate molecules, was used to study the EP film formed on cast iron cams and tappets run in motor oils containing this additive. The sulfur content of static films increased with immersion time and temperature and the presence of phosphate-coated metal surfaces. The bound sulfur of films formed during dynamic tests increased with running time, load, and with the use of phosphate-coated surfaces. These conditions also influenced the ratio of Zn:P:S contained in both static and dynamic films. Zinc and phosphorus in the films increased more rapidly than the sulfur with increased temperature and/or pressure. The dynamic films are not easily worn off by running in non-additive oil. The mechanism of action of zinc dithiophosphates appears to be related to chemical reactions of additive decomposition products with the metal surfaces to form tightly-bound solid films which reduce damage under extreme pressure conditions. Radioactive counting and X-ray spectroscopy were used to determine the amount of sulfur and zinc on tappets; autoradiographs showed the concentration and distribution of the sulfur on cam and tappet surfaces.

TEST PROCEDURES FOR THE EVALUATION OF CUTTING FLUIDS, by R. J. Yanis and G. F. Wolfe, Gen. Elect. Co., West Lynn, Mass., 59AM 2A1.

This paper deals with the laboratory evaluation of cutting fluids. The procedures described are part of a departmental program designed to screen and evaluate cutting fluids for shop applications. The paper reviews bench procedures for evaluating rust preventative characteristics, emulsion stability, and resistance of mulsion to mold and odor formation due to contamination and gumming tendencies. Machinability tests are described in the second part of the paper. The testing procedure has been chosen so that statistical evaluations may be used for determining reliability of test data and establishing levels of significance for comparing cutting fluids. In each evaluation, the fluid undergoing tests is compared against a reference fluid under carefully controlled laboratory conditions. Test results comparing soluble fluids, applications, concentrations and results using straight oils as well as water are described in detail.

N. C. DERBY

Preprint 59AM 2A2

NEW DEVELOPMENTS IN METAL WORKING, by E. L. H. Bastian, I. Rozalsky, K. F. Schiermeier, Shell Oil Company of New York, 59AM 2A3.

Today's most acute metalworking problems are related to the forming of high melting-point, refractory, and reactive metals and the machining of these and other super alloys.

Requirements for alloys having high rupture strength at temperatures approaching the metal melting point, particularly in the aircraft and missile fields, have occasioned the advent of such new materials.

Since unique requirements for mechanical and metallurgical use entail costlier economics both in alloy manufacture and fabrication, new methods and tooling are indicated.

However with respect to metalworking fluid usage, basic fundamentals by which fluids function are relatively unchanged, whether for newer unique operations or for more conventional methods by which the bulk of metalworking is accomplished.

C. D. FLEMMING

Preprint 59AM 3A2

EFFECT OF THICKENER-PARTICLE DIMENSION ON LUBRICATING GREASE PROPERTIES, by R. H. Leet, A. C. Borg, Standard Oil Co. Whiting, Ind., 59AM 2B2.

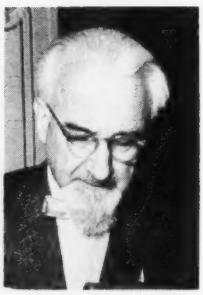
One of the factors affecting properties of lubricating grease is the size and shape of the thickener particles. The effect of the length-to-width ratio of thickener particles on mechanical stability, age-hardening, and leakage of grease was studied. Four greases were made from lithium hydroxy stearate and a mineral oil. The greases were alike in thickener concentrations and consistency but differed in thickener-particle dimensions as measured from electron micrographs. Increases in length-to-width ratio increased mechanical stability and leakage and reduced age-hardening. Although observed with lithium-soap greases, the same trends should occur with other greases.

J. J. FLOREK

Preprint 59AM 1A2

LOW SHEAR RATE GREASE MOBILITY, by Eldon L. Armstrong, Socony Mobil Oil Co., Brooklyn, N. Y., John Simon, National Tube Division U. S. Steel, McKeesport, Pa., 59AM 2C1.

Grease pumpability was a serious problem when cen-



G. H. von FUCHS

Preprint 59AM 2B4

M. A. HANSON

Preprint 59AM 3C2

tralized dispensing systems were first introduced to industry almost three decades ago. In this paper, it is shown that the shear rates existent in long-line industrial systems are well below the 10 reciprocal seconds level which is currently in use with present ASTM methods. Exploratory laboratory work and an investigation of a critical long-line industrial system have shown that the shear rates range as low as .05 reciprocal seconds, particularly in large diameter piping. The data provide a method of calculating pressure drop in long-line systems with good agreement with the observed readings. With this information as background, criteria can now be developed for evaluating greases and long-line systems at low temperatures.

E. F. HARCHELROAD

Preprint 59AM 5B1

REDUCING LEAKAGE FROM HYDRAULIC SYSTEMS, by Robert Q. Sharpe, Socony Mobile Oil Co., New York, 59AM 2C2.

Many plants have found that a carefully conceived program of preventive maintenance provides a fully satisfactory answer to the control of leakage from hydraulic systems. This involves a careful study of the hydraulic systems in the plant to determine which are the worst leakers. A study of the operating cycle and mechanical design then makes possible the development of a carefully planned preventive maintenance program. Such a program requires the training of the maintenance personnel in the design, use, limitations and operating requirements of the various elements required to reduce leakage from both moving and static joints. Experience has documented the fact that such programs can be effective and economical to install.

N. R. HOSTLER

Preprint 59AM 2C4

PRACTICAL DISCUSSION OF LUBRICATING OILS AND GREASES AVAILABLE FOR INDUSTRY, by Norman R. Hostler, Tidewater Oil Co., N. Y., 59AM 2C4.

The intent of this paper is to provide a broad background on lubricating oil processing. It is directed to the consumer rather than to the petroleum technologist. Such information may be of assistance in selecting the proper type of lubricant for a particular use as well as promoting a better understanding between consumer and supplier.

Charts reveal 11 basic lubricating oils. The various viscosities in which each grade can be produced multiplies the number greatly.

Sixteen or more straight run viscosity fractions represent the basis of the entire petroleum lubricating oil field. The average major oil company may have available as many as 300 or more distinct and different lubricants. How is this obtained from say 16 or 20 basic lubricating oil stocks?

M. JACOBSON

Preprint 59AM 4A1

MODERN TECHNIQUES FOR SPRAY LUBRICATING INDUSTRIAL GEARING, by E. J. Gesdorf, Senior Application Engineer, The Farval Corp., Cleveland Ohio, 59AM 2C5.

This paper covers 18 years of development and progress with spray lubricating equipment for open gearing. The paper starts with the origination of the idea and discusses the step-by-step sequence that transformed the original idea into the broadly accepted modern centralized spray lubricating systems that we know today.

The outstanding feature of a centralized spray lubricating system is that air and lubricant can be controlled and applied in exactly the quantities required. This substantially reduces the cost of lubricating open gearing and at the same time provides better lubrication for this type of gearing.

After an insight into spray system development problems, the paper concludes with a short discussion of present trends and a glimpse of what is ahead for this type of equipment.

R. L. JOHNSON

Preprint 59AM 1A4

IMPORTANT FACTORS IN THE SELECTION AND USE OF WATER SOLUBLE CUTTING AND GRINDING FLUIDS, by C. A. Sluhan, Master Chemical Corp. Toledo, Ohio, 59AM 3A1.

The paper describes the theory of chip formation in machining and grinding and develops it through the stage of friction (internal and external), heat generation, and dissipation. The inter-relationship of unit pressure, time and temperature results from changes of tool design and of speeds and feeds. The chemical and physical nature of various cutting and grinding fluids is illustrated and it is shown how the complex inter-relationship of unit pressure, time and temperature demands varying physical and chemical characteristics of fluids for most efficient metal removal rates. It also shows how grinding components are similar, yet different from cutting tool applications.

The influence of metallurgy of piece parts on tool life is illustrated as are a few cases of production jobs.

E. P. KINGSBURY

Preprint 59AM 3B4

CONTROLLING SPOILAGE OF WATER-SOLUBLE CUTTING FLUIDS, by C. D. Flemming and R. J. Baker, Socony Mobil Oil Co., 59AM 3A2.

During metal cutting operations, a particular type of sulfate reducing bacteria Sporovibrio desulfuricans was found highly responsible for spoilage in most cases. A description of the bacteria, its sources and environmental conditions favoring its propagation are given. An electrochemical action is described which is believed to be of value in controlling bacterial spoilage concerned pH of emulsions, metallic turnings in system, emulsion temperature, aeration, housekeeping, bactericides, and sulfur content of metal machined.

A case history of combating emulsion spoilage in a metal plant is related.

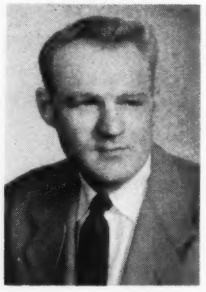
J. B. KIRSCHNER

Preprint 59AM 2C4

COOLANT MICROBIOLOGY: THE ROLE OF INDUSTRIAL RESEARCH, by E. D. Kitzke, R. J. McGray, S. C. Johnson & Son, Inc., Racine, Wisc., 59AM 3A3.

Various microbiology problems, associated with different coolant products, which occur under field conditions are discussed and possible lines of attack to solve these problems are elaborated.

Industrial users of coolants can play a role in minimizing these problems but the coolant manufacturer probably will have to make specific recommendations and assume the educator's role. Special microbiological techniques are required to evaluate the effectiveness of cidal additives under laboratory and field use conditions. Because there are inherent problems associated with the use of cidal additives, stringent screening criteria should be established.



E. D. KITZKE

Preprint 59AM 3A3

R. H. LEET

Preprint 59AM 2B2

DEVELOPMENTS IN RAILROAD JOURNAL BEARINGS, by M. A. Hanson, Magnus Metal Co., Chicago, Ill., 59AM 3C2.

The development of the solid railway journal bearing is traced from its early development. Major design changes of 1942 are evaluated by comparing two surveys of scrap bearings. The design changes appear to have substantially changed the pattern of end wear. Two other recent surveys of scrap bearings show conclusive evidence of undesirable bearing load distribution. Many bearings are more heavily loaded at one end or at both ends than in the middle where the oil film would be best able to carry the load.

The designs of recent experimental bearings which have been field-tested are discussed. An additional experimental design is proposed for field testing.

E. H. LOESER

Preprint 59AM 1C4

THE CONTRIBUTION OF POLYMERS TO OIL PROPERTIES IMPORTANT TO ENGINE LUBRICATION, by J. M. Musselman and S. M. Darling, Standard Oil Co. of Ohio, 59AM 3B3.

Experimental data concerning the influence of polymers on oil properties important to lubrication of automotive engines is discussed. Low temperature viscosity is related to start-up lubrication, high temperature conventional viscosity to low oil consumption, high shear viscosity to low engine friction. The relationship between polymer content of oils and amount and distribution of contaminants and deposits accumulated in the engine during service is shown. Justifications for multi-grade motor oils are illustrated by the favorable influence of polymers on the above properties.

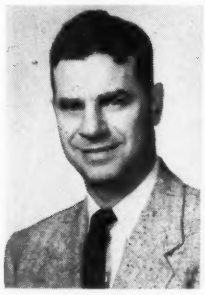
R. J. McGRAY

Preprint 59AM 3A3

HEAT OF ADSORPTION OF A BOUNDARY LUBRICANT, by E. P. Kingsbury, Massachusetts Institute of Technology, Cambridge, Mass., 59AM 3B4.

In the case of physical bonding, the heat of adsorption of a boundary lubricant on a bearing surface has been shown to determine frictional behavior. The theory is here extended to include the effects of temperature and velocity on wear, and corresponding experimental results are presented.

The mathematical form of these dependances is discussed and a characteristic temperature defined and calculated. As a result, a class of very high temperature boundary lubricants is suggested and some further experimental results summarized.



J. MESSINA

Preprint 59AM 3B2

BEHAVIOR OF VISCOSITY INDEX IMPROVERS IN LUBRICATING OIL, by Robert Byrne, Association of American Railroads, Chicago, Ill., 59AM 3C1.

A study has been made of the application of polymeric materials to petroleum oils for the purpose of increasing the viscosity of the oils. A theory of viscosity is discussed which represents the behavior of long chain polymers within the lattice structure of a fluid. This theory has been used to explain the changes that occur in the viscosity of polymer and oil blends under various rates of shear. The temperature dependence of viscosity for fluids containing viscosity index improvers is also examined.

Georgi has shown that oils containing viscosity index improvers suffer temporary viscosity loss during high rates of shear. Work conducted and sponsored by the Association of American Railroads relates the perma-

nent viscosity loss of polymer and oil blends caused by polymer rupture due to shear in a simulated full scale railroad car journal-bearing system. The effectiveness of viscosity index improvers in lubricants is reduced because of their shear susceptibility, thus causing viscosity of the blend to approach the base oil viscosity during severe operation.

THE FINITE FITTED PARTIAL JOURNAL BEARING, by M. Jacobson and E. Saibel, Rensselaer Polytechnic Institute, Troy, N. Y., 59AM 4A1.
An exact solution is found for the finite fitted journal bearing. Numericals calculations are carried out for arc of 60° and 120° for various bearing positions. Comparison is made of load, pressure distribution, and friction force for the finite bearing and for the infinite bearing (no side flow). In general, neglect of side flow yields a solution that may be in great error.

EFFECTS OF FLUID FILM PRESSURE ON HYDRODYNAMIC LUBRICATION, by N. Tipei, Institute of Applied Mechanics, Bucharest, Romania, 59AM 4A3.
The effect of pressure upon hydrodynamic lubrication is reflected by lubricant density and viscosity variation. Proceeding from the relation which relates density to pressure for liquids, the author obtains the differential equation of a variable π upon which pressure and other characteristics depend. This equation is integrated for two-dimensional motion and as an application the problem of plane surfaces and constant viscosity is discussed.
It is shown that a paramenter K has a predominant influence upon the pressure curve. For small values, the pressures differ only slightly from those for fluid. For large values, the pressures as well as other properties present considerable difference.
For circular cylindrical surfaces, the density depends upon an integral expression whose solution is obtained by means of conventional graphical and numerical computations. By admitting that viscosity varies with pressure, a general method for solving the two-dimensional problem is given.

LUBRICATION! SEZ WHO? by R. L. Churchwell and F. J. Takas, Tennessee Gas Co., Houston, Tex., 59AM 4B2.
The correct forced-feed lubrication of a gas engine has long presented an operational difficulty. Laboratory investigations of the "drop-counting" and "turns" methods of adjusting the delivery rate were made on both the vacuum and the sight-feed types of lubricator pumps. The widely varying results necessitated the development of a new method for directly measuring the stroke of the positive displacement type pump. The new method was then tested for delivery against atmospheric and higher pressures. A set of delivery charts was compiled for field use. Also, a preliminary investigation was conducted on the effect of high oil temperature and O-ring performance.
A field modification method and kit were developed and a program of modification initiated, which resulted in the modification of some 10,000 pumps. The program has initially resulted in a new awareness and consciousness of the importance and complexity of lubrication. Appreciable oil economics have also been achieved.

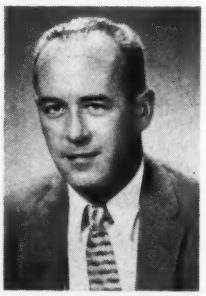
B. L. MORDIKE

Preprint 59AM 1A3

A. S. MORROW

J. R. MUENGER

Preprint 59AM 2A2



S. F. MURRAY

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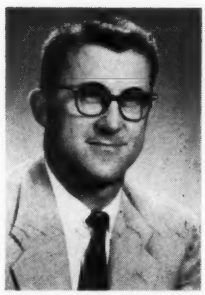
J. M. MUSSELMAN

Preprint 59AM 3B3



M. B. PETERSON

Preprint 59AM 1A2

W. PELINO

Preprint 59AM 3C3

W. S. ROUVERAL

Preprint 59AM 5A2

BRIEF EXAMINATION OF FACTORS AFFECTING TRACTIVE FRICTION COEFFICIENTS OF SPHERES ROLLING ON FLAT PLATES, by W. S. Rouverol, University of Calif., Berkeley, and R. L. Tanner, Manchester University, England, 59AM 5A2.

The recent observation that a sphere which rolls without sliding between two opposed non-coaxial rotating disks describes a perfect circle, has led to the development of a new type of variable speed transmission. This device employs a large number of ordinary ball bearing balls mounted in rotatable cages and pressed between hardened steel disks. Considerable torque can thus be transmitted from one disk to the other at speed ratios varying with relative distance of cage axis from disk axes. To maximize the capacity of this type of friction drive, as well as that of any type of ball-disk drive or integrator, investigation was made into factors governing tractive capacity of steel balls rolling on flat steel surfaces. The coefficient of tractive friction, defined as the ratio of tractive force to normal force at a specified slip rate, was observed to depend on lubricant properties and ball diameter, but to be relatively independent of normal load and rolling velocity. Coefficients of 0.08 were found to be attainable using conventional lubricants.

BEHAVIOR OF LUBRICATED BALL BEARINGS IN CONTROLLED ATMOSPHERES, by W. A. Glaeser, Battelle Memorial Institute, Columbus, Ohio, 59AM 5A3.

Ball thrust bearings have been operated in high-purity oxygen-free dry gas atmospheres at 200F and their performance studied. Bearings were flood lubricated with commonly used oils. The gas atmospheres used included nitrogen-hydrogen mixture, hydrogen, and helium. The bearing loads ranged from 200,000 to 250,000 psi Hertz stress. Operation in these gases was compared with operation in air. In general, bearing operation in the pure gas environments was satisfactory. Some increase in bearing wear and friction was noted when compared with runs made in air. Bearings run in pure, dry hydrogen exhibited the most pronounced difference in appearance after operation. The wear tracks in these bearings were highly polished, the finish being almost equal to a metallographic polish.

LUBRICATION OF SOLIDS AT VERY HIGH TEMPERATURES, by Barry L. Mordike, University of Cambridge, England, 59AM 1A3

Boundary lubrication of metal surfaces depends upon the existence of a layer of lubricant which prevents gross metal contact and which shears easily. At elevated temperatures, conventional lubricants melt or desorb and are relatively useless. For effective lubrication at these high temperatures, it is necessary for the lubricant to remain solid and to be sheared easily. Lamellar solids appear to possess these properties and a detailed study has, therefore, been made of the behaviour of graphite, boron nitride, molybdenum, disulphide and talc.

Earlier work suggested that with such materials sliding occurs by shearing across the lamellar planes of the crystals. The present study suggests that cleavage of individual crystals is unusual, most of the sliding occurring between one crystallite and its neighbour;

the friction being dominated by the forces between existing crystallites. The large plate-like surfaces of the crystallites are low energy surfaces and have little mutual interaction. The edges are generally high energy surfaces and if clean, can exert strong forces on neighbouring crystallites. These edges can react with gases to give a surface of relatively low surface energy and the adhesion between the crystallites then becomes small giving low friction and wear. The removal of the adsorbed gases generally increases the friction as is observed in the case of physically adsorbed volatiles from boron nitride and chemically bound carbon oxides from graphite.

Electron diffraction studies show that on rubbing, lamellar solids tend to form oriented layers, the plate-like crystallites lying flat. The orientation itself does not cause the low friction, but the low adhesion between the crystallites allows them to orient themselves most favourably, independently causing the friction to be low.

Experiments dealing with the lubrication of molybdenum in hydrogen sulphide gas are also discussed. The layer of MoS_2 formed is a better lubricant than layers of MoS_2 applied conventionally, probably because of the better attachment of the layer to the substrate metal, and will lubricate up to 700°C in air.

The last section deals with the friction of pure metallic carbides at temperatures above the range of other lubricants. The carbides investigated show first a decrease in friction, and then at temperatures of 1,000°C it rises steeply. The reason for the decrease is uncertain but the sharp increase may be associated with a softening of the carbide. The carbides were studied in vacuum to avoid oxidation and surface contamination.

TWO MEASUREMENT TECHNIQUES USED IN THE EVALUATION OF CUTTING FLUIDS, by J. R. Muenger and N. C. Derby, 59AM 2A2

Various criteria have been used in metal cutting fluids e.g. tool-life, wear, temperature and forces, work surface finish, and chip deformation. In each case, a number of measurement methods may be employed. This paper describes two very simple means of measurement which have been found useful in cutting fluid research. The first is based on measurement of work surface finish in the direction of cut by determining the amount of pencil lead abraded by the surface under controlled conditions. The second is based on measurement of chip deformation by electrical resistance determination of chips from a known length of cut.

LUBRICATION IN THE PROCESSES OF METAL DISPLACEMENT, by S. J. Barber, 59AM 2A4

In the shaping of metals, the processes employed may be divided into two major classifications, metal removal and metal displacement. In the latter category, the relative importance of the factors to be considered in choosing the best lubricant is set forth. The processes of metal displacement under pressure or impact may be employed over a wide temperature range. Temperature is the first consideration in the selection of a lubricant.

The need for cooling, the severity of the operation,

I. ROZALSKY

Preprint 59AM 2A3

E. SAIBEL

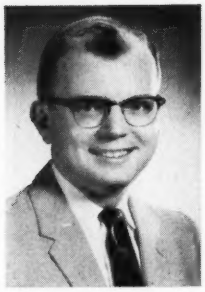
Preprint 59AM 4A1

K. F. SCHIERMEIER

Preprint 59AM 2A3

R. Q. SHARPE

Preprint 59AM 2C2



L. B. SIBLEY

Preprint 59AM 1A1

J. SIMON

Preprint 59AM 2C1

H. E. SLINEY

Preprint 59AM 1A4

C. A. SLUHAN

Preprint 59AM 3A1

methods of application, cleaning and storage as well as subsequent operations are reviewed as factors in lubricant selection.

Procedures employed in the evaluation of forging agents have contributed greatly in the simplification of lubricant selection. The correlation of a test procedure with production requirements is discussed.

FLOW PROPERTIES OF LITHIUM STEARATE-OIL MODEL GREASES AS FUNCTIONS OF SOAP CONCENTRATION AND TEMPERATURE, by Walter H. Bauer, A. P. Finkelstein and S. E. Wiberley, 59AM 2B2

Lithium stearate-oil greases having 4, 8 and 12 per cent soap were prepared and flow properties of the greases were investigated, at 0, 25 and 37.8C. Flow data were obtained with a cone and plate viscometer equipped with automatic programming and recording of shear stress versus rate of shear, and of shear stress versus time at selected shear rates. Flow curves, shear stress versus shear rate, were obtained for an initial and a repeat 340 second cycle measured for highly worked samples, previously sheared at 19,000 $sec.^{-1}$ for 1,000 seconds. The rate of change of shearing stress required to maintain a constant rate of shear was measured at nine shear rates in the interval from 190 $sec.^{-1}$ to 19,000 $sec.^{-1}$. Similar flow measurements were made on greases containing stearic acid additives.

Initial flow resistance, ascribed to soap structural elements, showed temperature and concentration dependence differing from that of the sheared soap, and was destroyed by continued shear or addition of stearic acid. Flow resistance of the sheared samples was dependent on both the magnitude of the shear rate and the time of subjection to the shear.

SHEAR STABILITY OF LUBRICATING GREASES VS. LUBRICATING PERFORMANCE, by C. J. Boner, Battenfeld Grease-Oil Corp., 59AM 2B3

Applications of lubricating greases can be divided into three classes, those where shear stability is desirable, those where shear stability is of secondary importance, and those where too great a shear stability is undesirable. Applications of the first class are stressed in this paper.

Reference is made to both specifications and uses where this quality has been found desirable. For example, AARR specification for Journal Roller Bearing Greases, which call for an original worked penetration of 340-370, permits only a maximum increase of 25 points after 100,000 double strokes in a standard grease worker. Also during an eight-week accelerated test in a bearing, equivalent to 47,880 miles, the penetration must remain within the limits of 325 to 385. Certain lubricants designed for this service which softened only 10 to 15 points in penetration after 100,000 double strokes in a standard grease worker have satisfactorily lubricated passenger equipment journal roller bearings for 350,000 miles.

Data will be presented to demonstrate that certain lubricating greases which showed relatively small penetration changes in bench tests gave better service results when used in vehicles than did other lubricating greases which softened to a greater extent in laboratory tests.

RAPID DETERMINATION OF HEAT CAPACITIES OF LIQUIDS OVER EXTENDED TEMPERATURE RANGES, by J. W. Barger, C. C. Bolze, R. L. Hughes and T. M. Medved, 59AM 3B1

Two primary functions of lubricants are reducing the conversion of mechanical energy to heat and removing the heat. The amount of heat removed and the operating temperature attained are directly related to the heat capacity and thermal conductivity of the lubricant. Modern technology requires high temperature lubricants. As a result, many new items are being synthesized and evaluated. It is necessary to know the heat capacity and thermal conductivity of these new oils, lubricants, hydraulic fluids, etc. for either designing equipment or predicting the utility of the material. This paper describes a rapid method of obtaining heat capacity over an extended temperature range. The design, construction and operation of an adiabatic calorimeter are described. The calculations and methods of measurement are unique in that they utilize the small unavoidable heat losses. The heat capacity may be obtained with less than five per cent error. Speed is the primary advantage of the system. For example, the heat capacity is determined at five temperatures covering the ambient to 500F range in six hours.

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Preprint 59AM 2B2

EVALUATION OF LONG CHAIN PHOSPHORUS COMPOUNDS AS LUBRICITY ADDITIVES, by J. Messina and Louise Peale, U. S. Army Corps., Pitman-Dunn Lab., Frankford Arsenal, Philadelphia, Pa.; B. Ackerman and R. Sasin, Assn. of American Soup and Glycerin, New York, N. Y.; and Daniel Swern, Eastern Regional Research Lab., Philadelphia, Pa., 59AM 3B2

A series of new long chain phosphates and phosphonates were examined for suitability as lubricity agents in bix(2-ethylhexyl)sebacate and mineral oil. Two and five per cent blends were subjected to extreme pressure, anti-wear, coefficient of friction, accelerated oxidation and rust prevention tests. The most effective anti-wear agents were diethyl stearoxy-ethylphosphonate and dibutyl leuroxypropyl phosphate. The most promising extreme pressure agents were di-(2-ethylhexyl)leuroxyethyl phosphonate, diethyl oleoxyethyl-and diethyl oleoxybutyl phosphates and dibutyl leuroxypropyl phosphate. Coefficient of friction measurements using steel on steel were generally satisfactory, and the low value of 0.04 for dibutyl leuroxypropyl phosphate, diethyl oleoxyethyl- and

R. C. WIQUIST

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G. F. WOLFE

Preprint 59AM 2A1

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S. B. TWISS

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R. J. YANIS

Preprint 59AM 2A1

diethyl oleoxybutyl phosphates is particularly promising.

The phosphate derivatives also improved oxidation stability of the diester, but there appeared to be no improvement in rust prevention in either the sabacate or mineral oil.

Coefficient of friction, oxidation stability, anti-wear and extreme pressure properties were compared to presently used hypoid gear oils. It was found that the long chain phosphorus additives compared favorably with the values determined on the commercial products.

INFRARED HOT BOX DETECTION, by W. Pelino and D. M. Key, Jr., Servo Corp. of America, New Hyde Park, Long Island, N. Y., 59AM 3C3

The discovery of infrared in 1831 had to await the development of the science of solid state physics before it could be used successfully in military and industrial applications. The wide infrared spectrum requires numerous detectors with varying sensitivities for successful operation in particular bands within this spectrum. All bodies above absolute zero radiate energies which are proportional to the fourth power of their absolute temperature, although any two given materials at the same temperature may not radiate equal infrared energies because of their surface properties. The modifying factor is known as emissivity. The journal box is an infrared radiator to its surroundings, and conversely the surroundings are radiators to the journal box. It is the net radiation difference which the detector measures.

Although hot box detection is not the solution to the problem of lubrication breakdown, early discovery of hot boxer or abnormalities may enable railroad research and engineering personnel to further their knowledge of hot box prevention. The new devices and lubricants designed to reduce hot boxes are performing their intended job. Yet paradoxically, their use gives rise to an even greater detection problem since the characteristic smoke and odor of hot boxes using old materials and oils is usually absent when new methods are used. This makes automatic detection systems mandatory.

PROGRESS IN ROLLER BEARING LUBRICATION, by Dr. O. J. Horger, 59AM 3C4

This paper presents laboratory and service performance data on grease lubrication of journal bearings on railway equipment. The discussion includes pertinent aspects of grease test procedures in the laboratory, including data on electronic microscope studies and CRC tests. Service performance presented includes a treatment of the present AAR 18-month relubrication period on freight equipment and progress being made toward extending this period.

LUBRICATION PROBLEMS IN THE CEMENT INDUSTRY, by E. F. Harchelroad, 59AM 5B1

This paper deals with lubrication problems encountered in the cement industry. The particular problem is dealt with after the manufacturing process has been described.

The suggestions are presented for the solution of the particular problems in the industry. A solution experienced by one plant is presented.

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Lubrication Abstracts

Edited by W. E. Campbell

Selected literature compiled by members of the Technical Committees and Industry Councils of the Society.

"Contribution of Optical Microscopy to Control and Examination of Lubricating Greases," by B. Bernelin, Inst. Français du Pétrole—Revue, v 13, n 6, 1958, pp 1021-39.

Ways and means are reviewed of using the optical microscope in the manufacture and the usage of greases. The techniques discussed include phase contrast, interference and polarized light microscopy. (*Abstracted by E. O. Forster*)

"Evaluation of Anti-seizing and Recovery-from-Seizure Properties of E-P Lubricants by the Four-Ball Testing Machine." by C. Paleari, A. Girelli, and C. Siniramed. J. Inst. Petroleum, v 44, n 414, 1958, pp 178-81.

The anti-seizing and recovery-from-seizure properties of E-P oils are evaluated with the four-ball E-P testing machine using a procedure similar to that employed for the determination of the mean Hertz load. Various E-P additives containing sulfur chlorine, phosphorus, and lead soaps are evaluated in the same base oil. The best results were obtained with sulfur containing additives which, however, appear to be corrosive to metal surfaces. (*Abstracted by E. O. Forster*)

"The Chemistry of Lubricating Oil and Fuel Additives," by D. D. Dodgson. Petroleum, v 21, n 4, 1958, pp. 119-23, 130.

A review of the knowledge of the nature of chemicals which are commonly used to improve the properties of lubricating and fuel oils. References are given. (*Abstracted by E. O. Forster*)

"Direct-Reading Spectrographic Control of Lubricating Oil Additive Manufacture," by W. A. Rappold (Oronite Chemical Co., Oak Point, La.) and R. E. Ramsay, Symposium on Railroad Materials—Lubricating Oils, ASTM Spec. Tech. Publication n 214 1957. pp 109-114.

Experience at the authors' plant is cited, where wet chemical analyses have been replaced by the direct-reading spectrograph. Excellent agreement of the two methods is obtained, and analytical time is reduced from 8 to 1½ hours. (*Abstracted by M. I. Smith*)

"The Application of X-Ray Spectrography to Refinery Control of Additive Metals in Lubricating Oils," by E. N. Davis (Sinclair Research Lab. Inc., Harvey, Ill.), ASTM Spec. Tech. Pub. n 214, 1957, pp 115-123.

The calibration and use of this instrument for specific metals are described. As compared to wet chemical methods, analytical time is reduced from hours to minutes. (*Abstracted by M. I. Smith*)

"Sampling of Lubricating Oil from Diesel Locomotives," by W. K. Simpson (EMD, General Motors Corp., La Grange, Ill.), ASTM Spec. Tech. Pub. n 214, 1957, pp 124-6.

A survey of the practices of railroads in sampling oils for spectrographic analyses is reported. A recommended procedure and sampling information data are given. (*Abstracted by M. I. Smith*)

"Methods for Spectrographic Analysis of Lubricating Oils," by F. R. Bryan (Scientific Lab., Ford Motor Co., Dearbon, Mich.), ASTM Spec. Tech. Pub. n 214, pp 127-31.

Results of a round-robin evaluation of various methods of spectrographic analysis are given. (*Abstracted by M. I. Smith*)

"The Evaluation of a Direct Emission Spectrographic Method for the Analysis of Lubricating Oils," by W. D. Perkins (Shell Oil Co., Martinez, Cal.), J. R. Miller and J. H. Moser, ASTM Spec. Tech. Pub. n 214, pp 132-9.

The rotating disk method is discussed. Additions of known metals to increase sensitivity, and interferences between metals are covered. (*Abstracted by M. I. Smith*)

"Direct-Reading Spectrographic Evaluation of Used Railroad Oils," by V. C. Barth (Chicago & Northwestern Railway System, Chicago, Ill.), ASTM Spec. Tech. Pub. n 214, pp 140-5.

The use of the Quantometer and several case histories at the author's laboratory are described. (*Abstracted by M. I. Smith*)

"Chromatography of Lubricating Oils for Diesel Locomotives," by E. R. Thomas (Southern Pacific Co., Roseville, Cal.), ASTM Spec. Tech. Pub. n 214, pp 146-50.

A method for preliminary examination of pentane and benzol insolubles in used oils by means of color patterns on filter paper is described. (*Abstracted by M. I. Smith*)

"Filtration of Diesel Engine Lubricating Oil," by S. L. Earle (U. S. Naval Engrg. Exp. Station, Annapolis, Md.), ASTM Spec. Tech. Pub. n 214, pp 151-69.

Bench tests conducted on full-flow filters and typical results are given. Characteristics of interest include pressure drop, filtering ability, resistance to shock, contamination of oil by filtration media. Full-scale engine tests are also described. (*Abstracted by M. I. Smith*)

"Kiln Car Bearing Lubricants," by W. C. Kiefer (Bel-Ray Co., Inc., Madison, N. J.) and H. A. Bedell. American Ceramic Soc. Bull., v 37, n 2, 1958, pp 85-90.

Properties of petroleum and synthetic oils, greases and solid lubricants are reviewed. Best performance is obtained with a graphite synthetic oil base grease gelled by an inorganic agent. The unspecified oil does not form a solid residue at high temperatures. (*Abstracted by M. I. Smith*)

"The Mechanism of Sludge Suspension in Engine Oil," by P. J. Agius (Esso Research Ltd.) and D. Mulvey, J. Inst. Petroleum, v 44, n 416, 1958, pp 229-42.

Electrical properties and settling tendencies of an engine sludge dispersed in oils containing various detergent additives are studied. It is concluded that metallic and non-polymeric organic additives function by forming an electrical double layer at the sludge-oil interface. Polymer additives show different properties which are thought to be due to a solvation effect. Discussors point out the pitfalls involved in working with a sludge which has been filtered, dried, and redissolved in fresh oil. A bibliography is appended. (*Abstracted by M. I. Smith*)

"Development of Radiation Resistant Lubricants," by R. Irving. Shell Aviation News, v 238, 1958, pp 14-15.

Studies of radiation effects on lubricants carried out at Shell's Thornton Research Center are described. Irradiation of hydro-carbon oils in a pile caused produc-

tion of radioactive isotopes as well as darkening and thickening of the materials. Aromatic hydrocarbons were found to be more resistant to radiation damage than paraffinic hydrocarbons and synthetic oils are least stable. Conventional soap-thickened greases are shown to lose their structure and become fluid when exposed to nuclear radiation. (*Abstracted by E. O. Forster*)

"Measurement of the Load Carrying Capacity of Oils and Emulsions in a Frictional Wear Balance," by E. H. Kadmer (presented at 2nd Verband Sueddeut. Mineraloelwirtschaft Tech. Meet. Stuttgart, Germany, Dec. 3-5, 1957): abstr. Erd. Kohle, v 11, n 3, 1958, p 202.

H. Reichert's frictional wear balance, which operates on the principle of the Timken test machine, comprises a stressed cylinder roll which is pressed by a double lever system against a rotating steel ring, the lower third of which is immersed in the test liquid. The amount of material rubbed from the cylinder roll by the ring increases with rotational speed, load and time. The effectiveness of a lubricant is determined by the size of the worn area after a given time, and the corresponding load-carrying capacity in kg. per sq. cm. can be determined from diagrams. (*Abstracted by E. H. Okrent*)

"Reduce Motor Bearing Maintenance through Proper Grease Selection," by E. R. Booser, Power, v 100, n 11, pp 96-9, 195.

The primary function of grease in motor bearings is that of providing a vehicle for supplying lubricating oil to the bearings. The amount of clean, stabilized lubricant needed for proper bearing operation is extremely small, but absolutely essential. However, in many cases the secondary functions of the lubricant, such as the prevention of rust and the protection from foreign matter will dictate the type that is to be used under a given set of conditions. Another selection criterion is the type of bearing construction. An example of this is illustrated by the fact that a different grease is required for a double sealed bearing than would be used in an open bearing. Ordinarily, the latter situation is the preferable of the two because fresh grease is employed as a purgative for the lubricant which it displaces. A table is presented for the purpose of serving as a guide for establishing maximum relubrication periods. The bases for the scheduling of such maintenance are size of the motor and operating conditions. Greases deteriorate because of oxidation, bleeding, evaporation and contamination of dirt and moisture. It has been found that one or more of these conditions prevails when a grease has lost about half of its oil content. Factors such as temperature, load and shaft speed influence the life of grease. A table of specifications and approximate costs for different performance requirements is included to serve as a guide in the selection of synthetic greases. The list takes in the complete range of present-day greases from low temperature diester types through high temperature silicone types. Grease types, including those of synthetic oil base, are discussed. A third table gives some typical characteristics of petroleum type greases. Because of the existence of extreme variations of properties of a group within a given soap type, care must be exercised in selecting specific greases for difficult applications. In electric motor applications, sodium, sodium-calcium, and lithium soap types are the most widely used. Inorganic thickeners such as clay and silica gel, developed to replace soaps, are not well-suited to electric motor service due to high bearing torque and improper feeding characteristics.

A prerequisite to the proper selection of grease is the understanding of the significance of the properties by which they are graded. The most common consistency test is the penetrometer. Stiffness specifications, as prescribed by the NLGI, are defined, because oil viscosity in the petroleum types affects bearing performance. Mechanical stability, bleeding and evaporation characteristics and oxidation stability are other selection criteria. (*Abstracted by William Rosenberg*)

(*Cont. on p. 176*)

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LUBRICATION ABSTRACTS

(Cont. from p. 174)

"Lubricated Friction Under Severe Conditions" (In French), by J. Pomey (Regie Nationale des Usines Renault, France). Rev. inst. franc. petrole. et Ann. combustibles liquides, v 12, n 6, 1957, pp 754-780 and nos. 7-8, 1957, pp 887-914.

The physical and chemical variables influencing boundary and extreme pressure lubrication are studied. The introduction to the paper analyzes friction between metallic surfaces, based on the theory of formation and shearing of microwelds. Part II explains how metal pretreatments, such as carbonitriding, sulfating, sulfonitrating, and phosphating prevent seizure. Experiments conducted with the four-ball machine in pure mineral oil using pretreated steel balls show the superiority of phosphating. In Parts III and IV, the author mathematically analyzes conditions on sliding surfaces, particularly those of the four-ball machine. An important point in the hypotheses concerns the distribution and removal of heat that is generated at the wear surfaces. Also the validity of introducing numerous and important simplifications in the calculations is considered. Mechanical variations such as radius of the track and lack of symmetry of motion creates experimental inaccuracies. In certain cases a maximum temperature of 824F is found to have existed on the track of the upper ball. This temperature is deduced from hardness measurements. This method of determining temperatures at the interface is considered to have great significance. In Part V, extreme pressure additives, are investigated with the four-ball machine. Compounds from certain chemical families are blended into pure mineral oil. Performance of the blends is measured by the time to seizure at certain initial loads, by the load causing seizure, and by the highest load not leading to seizure. The following conclusions are reached: (1) The more dissociated an acid is, the more active it is in preventing seizure. (2) Mercaptoundecenylenic acid is distinctly more efficient than dibenzyl disulfide. (3) Chlorinated products are more efficient if they contain a mobile chlorine. (4) The simultaneous action of a chlorinated and sulfurated product is more efficient than either product alone. (5) Organic molecules which have been both chlorinated and sulfurated can perform as well as mixtures of chlorine or sulfur compounds. In another set of experiments steel balls are treated to produce a black film by heating them in the blends for 24 hours at 212F. The pretreated balls are run in the four-ball machine with pure mineral oil. The pretreatment in dibenzyl disulfide has a weak effect compared to pretreatment in tetrachlorobutyric acid. A distinct improvement in performance is obtained by running dibenzyl disulfide pretreated balls in mineral oil containing tetrachlorobutyric acid. The reverse is detrimental. In Part VI, the domains of hydrodynamic lubrication, lubrication by oiliness additives, and lubrication by chemically reactive additives are defined in terms of pressure (P) and sliding velocity (V). The domains are graphically represented on P-V diagrams. A zone of unavoidable seizure and two zones where more than one domain can exist are found. With the Amsler machine certain intermediate domain values of P and V can be realized. With the rotating cylinders arrangement of this machine, an oil wedge is encouraged and excellent lubricating conditions prevail, provided the surfaces are polished. Wear is measured, and various surface treatments of the rollers are evaluated with the Amsler machine. It is found that wear can be suppressed by very great surface hardness such as that produced by carbonitriding. Sulfating and phosphating reduce wear very little although they counteract seizure. The advantages and disadvantages of the several process are weighed. (*Abstracted by Douglas Godfrey*)

"Lubrication with Molybdenum Disulfide Formed from the Gas Phase," by F. P. Bowden and G. W. Rowe, Engineer 204, n 5311, November 8, 1957, p 667.

Further evidence is presented that films formed by heating molybdenum in hydrogen sulfide or in carbon disulfide vapor can give low friction at high temperatures even in vacuum. If destroyed during rubbing, these films can be reformed in hydrogen sulfide gas. It is shown that hydrogen sulfide or any gas in general may act as a lubricant provided it reacts with the surfaces to form a compound of appropriate structure. These conclusions are said to apply to other substances such as titanium iodide that have a layer lattice structure and form surface films giving low friction. (*Abstracted by E. O. Forster*)

"Lubrication of Rotary High Vacuum Pumps," by A. C. Smith (Shell Petroleum Co., Ltd.). Scientific Lubrication, v 9, n 10, 1957, pp 14-20, n 11, pp 12-16.

Degrees of vacuum and units of measurement are reviewed. Operation of rotary and diffusion pumps is explained. Harmful effects of contaminants—particularly water—are described, and means of preventing contamination of the oil are discussed. These include trapping, gas ballasting, and heating the lubricant. Ranges of vapor pressures of typical oils, and recommendations for various pumps are given. (*Abstracted by M. I. Smith*)

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"Effects of Hydraulic Fluids on Mechanical Packing Materials," by L. R. Tharp, E. F. Houghton & Co., Cleveland, Ohio.

Compatability of hydraulic fluid and packing material relates to the ability of the latter to perform efficiently the desired sealing function without excessive wear or frictional load. This requires consideration of pressures, shock loads, clearances, surface finish, temperature and frequency and durations of work cycles. Any one or a combination of these factors can cause volume change in a packing material according to its type and the nature of the hydraulic fluid. As a rule, fluorinated materials are an exception; others such as certain synthetic rubbers have been noted to undergo close to one-third volume change.

Hydraulic fluids are grouped in three general classifications—(1) water, (2) mineral oils and (3) fire-resistant fluids.

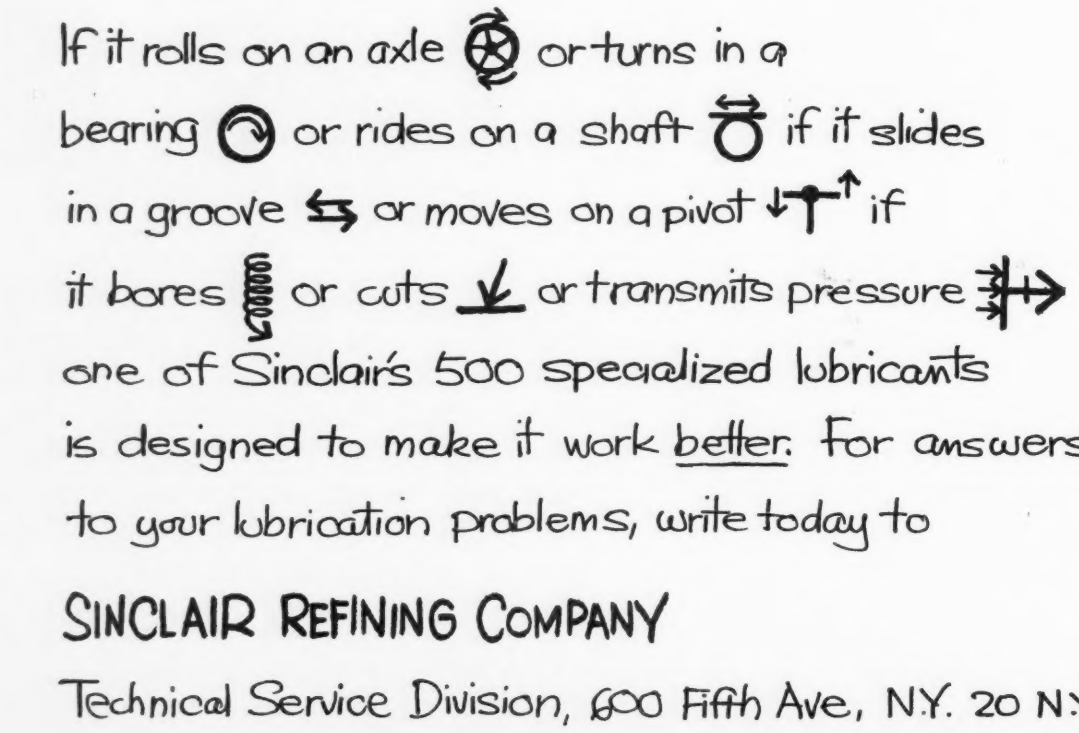
The normally acceptable packing materials include synthetic rubber of the Buna *N* type, fluorinated compounds, silicones, fabric and rubber combinations and leather.

In the case of water, the temperature must be below the boiling point. Affinity for water as well as temperature increase can influence swelling or shrinkage tendencies. The more inert the material, the better its resistance to volume change. Where high clearance or rough surface applications are involved, a certain amount of swelling may be desirable, as with leather or certain fabric-rubber materials.

Buna *N* is among the most satisfactory packing materials used with mineral hydraulic oils for temperatures up to around 300F. Here the oil's aniline point is significant as an indicator of the oil's possible effect on volume change of the packing material. Since certain types of mineral oils can have a marked effect on volume change of the packing material, the aniline point must be given careful consideration in selecting oil originally or when changing oils.

Fire resistant fluids are divided into three general classifications, (1) straight synthetic fluids, (2) water-glycol fluids and (3) water-mineral oil emulsions.

Fluorinated packing materials and silicone combinations are least affected as to volume change by the synthetic fluids. Water-glycol fluids, while usable in any unit containing packings designed for mineral oil, may have limitations where butyl packing installations are subject to mineral oil contamination. Wherever water may be used, however, as for example in the water-glycols or water-mineral oil emulsions, the corrosion potential must not be overlooked. In other respects any packing material satisfactory for mineral oil is acceptable for emulsion fluids with due consideration of the high temperature limitations. (*Digested by A. F. Brewer*)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Intensification of Research Effort Needed on Boundary Friction and Wear

Boundary friction and wear, the greatest source of industrial waste and the strongest single barrier to any substantial increases in the productivity of our machinery, is still a very complex phase of engineering.

It is a national military and industrial problem.

The slow progress in this particular phase of engineering can be attributed to the delayed recognition of the seriousness and complexity of the problem, to educational neglect, and to the refusal of engineering as a whole to accept responsibility for these deficiencies. The solution was thought to be the primary responsibility of the lubricant manufacturers.

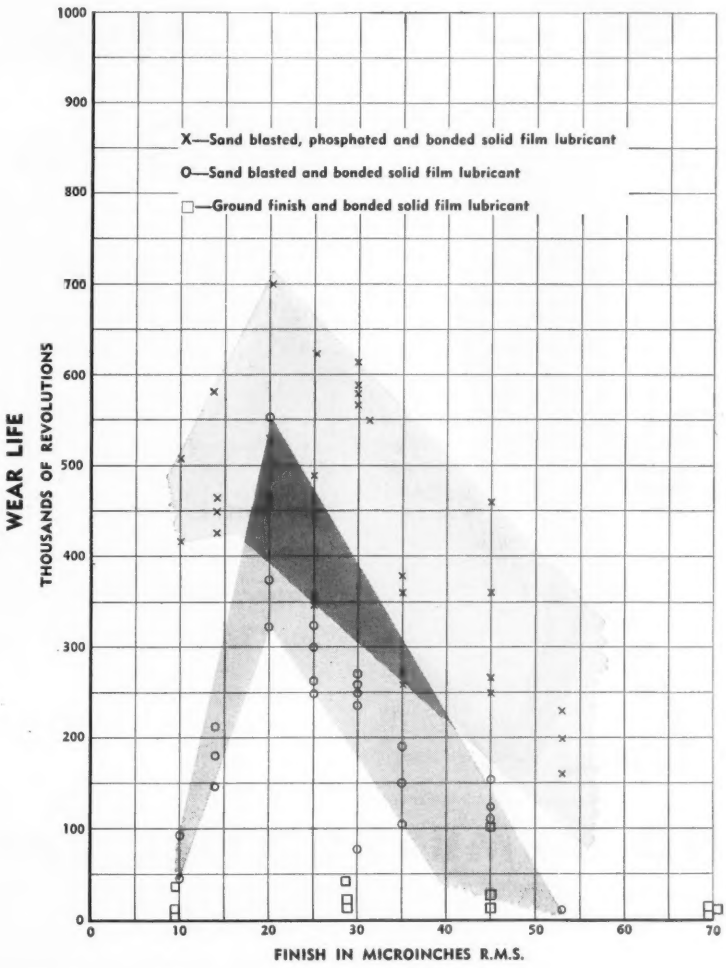
As one of these lubricant manufacturers, we take this responsibility seriously. After years of experience, we have found that the eventual elimination of boundary friction and wear as a complex will be based on *testing . . . testing . . . and more testing.* We feel that it is unrealistic to complain that the few E.P. testing machines in use do not solve the whole complex for us.

We want all the reliable testing machines we can afford and we now have 14 of one type, our Model LFW-1, in operation. Finally, we are beginning to see light after more than 100,000 testing hours on these machines. Yet, we realize that we have only begun to scratch the surface!

For example, it took 7,000 testing machine hours to plot the chart on this page which indicates the significance of surface finish and the methods used to produce it. A sharp wear-life peak appears for surfaces ground to 8 to 10 microinches r.m.s. and then sandblasted to a 20 microinches r.m.s. finish. It drops off sharply for finer or coarser finishes produced with other sizes of blasting media. Wear life is lowest for ground finishes.

Of course, surface roughness is only one of the many ingredients which make up the complexity of boundary friction and wear. A large number of these ingredients has shown up in our test data and will have to be investigated separately.

To complete the study of the effect of the surface finish alone for conditions other than those used in our tests, such as: a large variety of mating metal combinations, bearing pressures, sliding velocities, etc., an estimate of 4,000,000 testing machine hours is probably on the low side.



WEAR LIFE VERSUS SURFACE FINISH curves show the significance of surface finish and the methods used to produce it. Tests were run on Alpha Model LFW-1 testing machines. The following key indicates the testing procedures used: X shows results of samples which were ground to 8 to 10 microinches r.m.s. and then sandblasted to finish shown. After sandblasting, these samples were phosphated and then coated with a bonded solid film lubricant; ○ shows the results on samples which were ground to 8 to 10 microinches r.m.s., sandblasted to the r.m.s. finish shown and then coated with a bonded solid film lubricant; □ shows results on a ground surface coated with a bonded solid film lubricant.

About half of the energy produced in the world today is consumed by boundary friction and billions of dollars yearly are lost to boundary wear. Even if we are willing to accept these losses, we can hardly accept the condition where tremendous engineering advances are made in other fields only to be retarded by the slow progress in the field of boundary lubrication.

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Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

Extreme Pressure Soluble Oil, Patent #2,848,416 (M. E. Gililland and R. C. Givens, assignors to The Texas Co.) A soluble oil composition suitable for heavy duty metal cutting operations comprising mineral lubricating oil as the major constituent, oil-soluble emulsifying agents in an amount sufficient to cause formation of oil-in-water emulsions on mixing the soluble oils with water, and the following additives in per cent by weight based on the soluble oil:

	Percent by wt.
Chlorinated dibenzyl disulfide	4 to 6
Chlorinated paraffin wax	3.5 to 5
Sulfurized sperm oil ...	3.5 to 5

Extreme High Temperature Grease Compositions, Patent #2,848,417 (J. W. Armstrong and H. A. Woods, assignors to Shell Development Co.) A grease composition having lubricating properties which comprises a major proportion of an oleaginous lubricating liquid and between about 10 per cent and about 60 per cent by weight, of an indanthrene compound melting above about 250F said liquid and compound being milled sufficiently to produce a composition of grease-like consistency.

Lubricating Compositions, Patent #2,848,418 (W. Muller and R. Raue, assignors to Farbenfabriken Bayer Aktiengesellschaft) A lubricating composition comprising a major amount of a mineral lubricating oil and a minor amount, sufficient to inhibit the oxidative deterioration of said oil, of an amide.

Process for Preparing Lubricating Oils, Patent #2,849,385 (J. H. Kirk, assignor to Sinclair Refining Co.) The method of producing nonadditive aircraft engine lubricating oil compositions consisting essentially of about 5 to 50 volume per cent of a refined neutral oil of a viscosity of about 300 to 600 sus at 100F and 50 to 95 volume per cent of a refined heavy mineral lubricating oil fraction of a viscosity of about 80 to 200 sus at 210F which comprises contacting the refined neutral oil fraction with about 1 to 5 lb. of acid activated clay per barrel at a temperature of about 325 to 450F, stripping said contacted neutral oil of components boiling at temperatures up to about 700F, separating the neutral oil from the clay, contacting the refined heavy lubricating oil with about 4 to 8 pounds of acid activated clay per barrel at a temperature of about 500 to 600F, stripping said contacted heavy lubricating oil of components boiling at temperatures up to about 700F, separating the heavy lubricating oil from the clay, contacting each of the acid clay-treated neutral oil and heavy lubricating oil components with about 2 to 15 lbs. of a neutral clay per barrel at a temperature of 275 to 350F, separating the oil components from the neutral clay and blending the recovered oil components to obtain a lubricating oil composition.

Silver Phosphates as Wear-Reducing Agents, Patent #2,849,397 (B. W. Hotten, assignor to California Research Corp.) A lubricating oil composition comprising a major proportion of an oil of lubricating viscosity and, in an amount sufficient to inhibit wear in said lubricating oil composition, a silver dialkyl phosphate containing a total of 24-44 carbon atoms in the alkyl radicals.

Mineral-Base Lubricating Oils and Methods for Using Same, Patent #2,849,398 (L. E. Moody and A. H. Popkin, assignors to Esso Research & Engineering Co.) A lubricating oil composition having a resinification index less than 20 mg/5 gr, comprising at least 75 weight per cent of a petroleum oil having an initial boiling point above 300F and a final boiling point below 600 F, both at 10 mm Hg abs, a viscosity in the range of 50 to 160 sus at 100F and in the range of 33 to 50 sus at 210 F, a pour point below 15F and a resinification index less than 10 mg/5 gr, and up to 25 weight per cent of additives improving the properties of said composition, said additives including in the range of 1 to 15 weight per cent of a viscosity index improver selected from the group consisting of polyolefins having a molecular weight in the range of 5,000 to 50,000 and polymethacrylate esters; in the range of 1 to 15 weight per cent of a detergent consisting of a phosphosulfurized hydrocarbon having a molecular weight in the range of 300 to 30,000 neutralized with a metal containing reagent; and in the range of 0.01 to 5 weight per cent of a zinc dialkyl dithiophosphate as an antioxidant.

Improved Lubricating Composition, Patent #2,849,399 (A. H. Matuszak and W. J. Craven, assignors to Esso Research & Engineering Co.) An improved lubricating oil composition having reduced deposit forming tendencies which comprises a major proportion of an extracted mineral lubricating oil boiling within the range of about 375 to 675F at 10 mm Hg and having a resinification index below about 20 mg/5 gms of oil, about 0.5 to 10 wt. per cent of a detergent selected from the group consisting of alkaline earth metal salts of C_4-C_{24} alkyl phenol sulfides and their phosphosulfurized derivatives and alkaline earth metal aromatic hydrocarbon sulfonates having molecular weights of about 800 to 1000, about 0.1 to 5 wt. per cent of zinc di (C_3-C_{12} alkyl)dithiophosphate, about 0.005 to 5.0 wt. per cent of C_{12}-C_{18} methacrylate polymer of 15,000 to 25,000 molecular weight, and an ester selected from the group consisting of the C_7 to C_{14} branched chain primary aliphatic alcohol esters of the dimer and trimer of linoleic acid.

Greases Thickened with Polyamido Acid Salts, Patent #2,849,400 (B. W. Hotten, assignor to California Research Corp.) A grease composition comprising at least 50 per cent by weight, of a mineral oil of lubricating viscosity, and, in an amount sufficient to thicken said lubricating oil to the consistency of a grease.

Grease Composition Containing Chloro-Sulfonated Polymer, Patent #2,849,402 (E. D. Rogak, assignor to Sinclair Refining Co.) A grease composition comprising a lubricating oil thickened to grease consistency with a metal base fatty acid soap and having incorporated therein a chlorosulfonated polymer, having a molecular weight of about 1100 to 118,000 of aliphatic unsaturated hydrocarbons having two to five carbon atoms per molecule in an amount sufficient to impart extreme pressure properties to the composition.

Refining Mineral Oil with Oxygen and Magnetically Separated Bauxite Containing Iron, Patent #2,850,433 (I. W. Mills and P. B. Murray, assignors to Sun Oil Co.) Method for reducing the mercaptan content of mineral oil which comprises contacting

mineral oil containing mercaptans in liquid phase in the presence of oxygen with magnetically separated bauxite containing about 20 to 70 weight per cent of iron compounds as Fe_2O_3.

Crankcase Lubricant for Spark Ignition Engines, Patent #2,850,450 (H. F. Galindo and J. A. Miller, assignors to California Research Corp.) An improved gasoline engine crankcase lubricant which meets the viscosity requirements of an SAE 10W oil at 0F and the viscosity requirements of an SAE 30 oil at 212F consisting essentially of the combination of (a) a hydrocarbon lubricating oil having a viscosity ranging from 5,000 to 8,000 sus at 0F, said oil comprising at least 85% of the final composition of the lubricant, (b) 2.5 to 5 per cent by volume of an oil-soluble, alkyl methacrylate polymer having alkyl groups of from 6 to 20 carbon atoms and a molecular weight between 100,000 and 500,000, (c) 30 to 60 millimols per kilogram of an inorganic metal base substance consisting of a dispersion of the product of reaction between an alkylene glycol of less than 5 carbon atoms and an alkaline earth metal base, (d) 0.1 to 2 per cent by weight of an oil-soluble polyvalent metal salt of an ester of thiophosphoric acid, and (3) 0.1 to 1.5 per cent by weight of an oil-soluble aliphatic polysulfide antioxidant.

Lubricating Grease Containing Water Repellent Aerogel, Patent #2,850,451 (A. F. Sirianni and I. E. Puddington, assignors to National Research Council.) A process of preparing a silica gel base lubricating grease whereby an increased thickening effect is obtained per given amount of silica gel which comprises acidifying an aqueous sodium silicate solution to precipitate a silica aquagel, conditioning said silica aquagel at a pH of 5 for a time in the range of ½ to 48 hours, washing the gel so conditioned with an aqueous medium, exchanging the water in the gel so washed with a mutual solvent for water and lubricating oil, and thereafter replacing said mutual solvent with a lubricating oil, the proportion of said gel being sufficient to thicken said lubricating oil to a grease consistency.

Lubricant, Patent #2,850,452 (T. P. Sands, J. B. Davis and E. P. Cunningham, assignors to Monsanto Chem. Co.) An extreme-pressure lubricating composition comprising a major proportion of a mineral lubricating oil and, based upon said oil, (a) from about 2 per cent to about 15 per cent by weight of an oil-soluble product obtained by chemically substituting a part only of the chlorine in a chlorinated aliphatic hydrocarbon material having from 2 to about 24 carbon atoms with an alkyl thiocarbonate group, and (b) from about 1 per cent to about 5 per cent by weight of an oil-soluble polyvalent metal salt of a thiophosphoric acid.

Corrosion Inhibited Oil Compositions, Patent #2,850,453 (E. K. Fields, assignor to Standard Oil Co.) A composition having corrosion and oxidation inhibiting properties comprising a major proportion of an oil and from about 0.0001 per cent to about 10 per cent of an oil-soluble reaction product obtained by reacting at a temperature of from 25C. to about 150C. 2,5-dimercapto-1,3,4-thiadiazole, an aldehyde containing from 1 to 30 carbon atoms and an organic hydroxy compound having the general formula ROH in which R is a hydrocarbon radical selected from the group consisting of an aliphatic radical containing from about 4 to 30 carbon atoms and an aromatic radical containing from about 6 to 40 carbon atoms, said reactants being used in the molar ratio of from 1:2:1 to 1:6:5 respectively.

Production of Greases by Alkali Fusion of Materials Containing Hydroxy Fatty Acid and Glycerine Radicals, Patent #2,850,454 (A. J. Morway, assignor to Esso Research & Engineering Co.) A process of preparing lubricating greases containing a major proportion of lubricating oil, which comprises charging to a reaction vessel a mixture consisting essentially of about 50 per cent of said proportion of a mineral lubricating oil and a minor grease making proportion of a soap-forming material containing the radicals of a high molecular weight hydroxy fatty acid having in the range of 18 to 20 carbon atoms per molecule and of glycerine in an amount corresponding to the glyceride of said acid, heating the mixture to a temperature in the range of 130 to 150F, adding to said heated mixture sodium hydorxide in an amount in the range of 100 to 125 per cent in excess of that required to saponify said soap-forming material, thereafter raising the temperature of the mixture to in the range of 300 to 350F, adding the balance of said lubricating oil to the mixture so heated, continuing heating to melt the mass and beyond this point to a temperature in the range of 510 to 550F sufficient to liberate gas and cause foaming, further raising the temperature to a level in the range of 530 to 570F until foaming subsides, cooling the mixture to a temperature in the range of 300 to 330F and adjusting the free alkalinity of the mixture to less than one per cent.

Lubricating Oil Compositions and Additives for Lubricating Oils, Patent #2,850,455 (R. Kern and H. Scheurer, assignors to Rhein-Chemie G.m.b.H) A new composition of matter suitable as an additive for mineral lubricating oils, said composition consisting essentially of a metal salt of a surface-active sulphonic acid of at least eight carbon atoms, and etherified polyalkylene-glycol of the general formula

$$HO—(R—O)_n—R—OY$$

wherein R is an alkylene radical having a minimum of two and a maximum of three carbon atoms, n is a whole number between one and 20 and Y is an alkyl radical having at least 12 carbon atoms, and a high boiling mono ether having a total of at least 12 carbon atoms and at least one of the radicals of which has more than 6 carbon atoms, said polyalkylene glycol derivative being present in an amount of 1 per cent to equal the weight of said sulfonic acid salt and said polyalkylene glycol derivative and said high boiling ether being present in an amount sufficient to cause dissolution of said sulfonic acid salt in a lubricating oil.

Grease Wherein the Thickener Comprises Metal Soaps of Hydroxy Fatty Acid Formals, Patent # 2,850,456 (A. H. Matuszak, A. J. Morway and J. C. Munday, assignors to Esso Research & Engineering Co.) A lubricating grease composition comprising a mineral lubricating oil containing combined therein a minor, but grease thickening, amount of metal soap of a formal of a hydroxy-fatty acid having from about 14 to 22 carbon atoms, said metal constituent being selected from the group consisting of alkali and alkaline earth metals.

Process for Preparing Mixed-Salt Grease Compositions, Patent #2,850,457 (R. A. Thompson, Jr. and J. F. Richards, assignors to Esso Research & Engineering Co.) In a process for the manufacture of a lubricating grease comprising lubricating oil and a grease thickening amount of a complex grease thickener comprising (1) an alkaline earth metal salt of a C_1 to C_6 fatty acid, (2) an alkaline earth metal salt of a higher molecular weight acid selected from the group consisting of salts of high molecular weight monocarboxylic acids and salts of intermediate molecular weight monocarboxylic acids, and combinations thereof, wherein said metal salts are formed in the presence of a lubricating oil and then are heated to a temperature conductive to the formation of a complex and are subsequently cooled; the improvement which comprises, initially forming a slurry comprising an alkaline earth metal base and at least a portion of the lubricating oil in a grease making zone, continuously withdrawing from said zone and circulating back to said zone a stream of said slurry, and slowly adding to said circulating slurry stream a stream of said C_1 to C_6 fatty acid, wherein the ratio of the rate of circulation of said slurry to the rate of addition of the C_1 to C_6 fatty acid is about 10:1 to about 100:1 by volume.

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Process for Preparing Mixed-Salt Grease Compositions, Patent #2,850,458 (A. Beerbower and H. E. Bloomsburg, assignors to Esso Research & Engineering Co.) A process for the manufacture of a lubricant comprising lubricating oil and about three to 50 weight per cent of a mixed-salt complex comprising alkaline earth metal salt of a C_1 to C_6 fatty acid and alkaline earth metal salt of a higher molecular weight fatty acid selected from the group consisting of intermediate and high molecular weight fatty acids and mixtures thereof, which comprises forming a slurry containing alkaline earth metal base and at least a portion of the lubricating oil, passing a stream of said slurry to a high intensity mixer, simultaneously passing to said mixer a second stream comprising said C_1 to C_6 fatty acid, one of said streams also containing said higher fatty acid, intensely mixing said streams in said mixer whereby said C_1 to C_6 fatty acid is dispersed in said slurry in the form of droplets of less than 0.05 mm. diameter, incorporating the remainder of said oil, heating to 250 to 550F and cooling to form lubricant.

Lubricating Grease Compositions Containing Soaps of Oxidized Petroleum Hydrocarbons, Patent #2,850,459 (L. A. Mikeska, A. J. Morway and C. A. Cohen, assignors to Esso Research & Engineering Co.) A lubricating grease composition comprising a major proportion of mineral base lubricating oil thickened to a grease consistency with a thickner consisting essentially of 5 per cent to 15 per cent by weight, based on the total composition, of an alkali metal soap of high molecular weight carboxylic acids derived from fatty materials, 5 per cent to 15 per cent by weight of an alkali metal soap of saponifiable materials produced by the oxidation of white oils which are highly refined petroleum oils of naphthenic tincture, and 2 per cent to 6 per cent by weight of a salt of a carboxylic monobasic acid containing one to 5 carbon atoms per molecule and a metal selected from the group consisting of alkali metals and alkaline earth metals.

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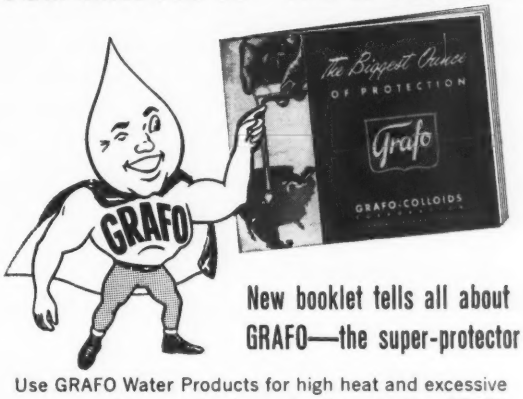

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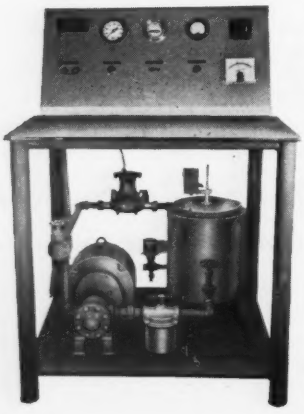

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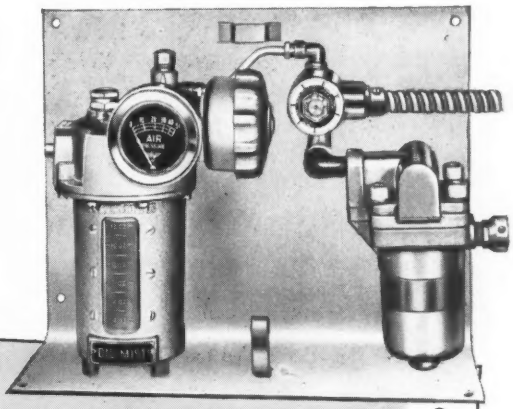

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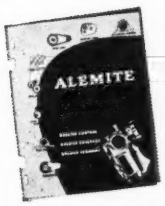

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